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# SOIL PROTECTION
*and*
# SOIL IMPROVEMENT

*By* JAMES E. RANDALL

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by
James E. Randall

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## PREFACE.

The need of complete information in one handy volume, in other words a ready reference book, covering the various phases pertaining to the Protection and Improvement of our soils, influenced the author in compiling the subject matter herewith set forth. The value of tile underdrainage in the up-building of the farm lands was considered of such vital importance that it is treated at length, showing the treatment and the results obtained in different types of soils. Then, too, since the farmer is deeply interested in all matters relating to the growing and handling of their crops, he should be greatly concerned in the proper expenditure of the public moneys for road building and in the securing for himself and his neighbors the best possible returns for such expenditure. The proper drainage of our highways has received less attention than the drainage of the farm. The lack of it, has resulted in the destruction of all kinds of roads and an inexcusable waste of money. In fact injury resulting from lack of drainage is greater than injury from traffic. The demand for better roads invites a study and knowledge as to how the money expended may not be lost. No class of taxpayers is more concerned than the farmer in the building of our roads so they will last. Hence, a portion of this book is given over to the subject of the Improvement of Our Rural Highways and an urgent appeal for earnest co-operation on the part of the farmer, for only through same can our people correct the present evil and make possible better conditions of traffic and the handling of the crops.

The author wishes to acknowledge his indebtedness for the data used secured from Prof. G. I. Christie and A. T. Wiancko, of the Purdue University Agricultural Experimental Station, The International Harvester Company, The Western Tile Underdrainage Bureau and the many farmers who gave me most courteous consideration and co-operation when I inspected their farms and enabled me to gather much valuable information.

JAMES E. RANDALL.

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# Soil Protection and Soil Improvement.

By James E. Randall.

**The Importance of Our Soil.** Did you ever ponder over the great vital importance of our soil? Take it away from this planet we are living on and what would happen? All vegetation would disappear in season, the streams would cease to carry any fertility on to the ocean. In time the fishes of the sea would be no more. When the storehouses were exhausted of their supplies, the fishes of the sea and the fowls of the air depleted, man would surely perish. So it can be truthfully said that soil is the source of all wealth and life and that all values, even our existence, depends on the soil. As we protect and improve our soil we safeguard and increase the security of our posterity. The soil is our inheritage. 'Tis our bounden duty to our children and our children's children to protect it, nourish it and improve it that we may give the farm lands to the next generation or our successors in as good if not better condition than in which we found them. So we must give deep careful consideration to the ways and means of properly working our farm lands.

**Soil the Work of the Ages.** To rightly understand our great responsibility in connection with soil protection and soil improvement let us dwell but briefly on one important point before taking up the many factors effecting our soils and the profitable and correct working of same.

The soil is a thin blanket or layer covering the earth, the accumulation of the ages, derived from our primitive rocks by the disintegrating process called weathering, the wearing and shifting powers of the elements and by glacial action. The doctrine that generally obtains is that lichens, the first occupants of the initial layer so formed, contributed by their life and death in turn to soil formation and thereby made life possible for the mosses and the succeeding plant growth. These in like manner yielded their increase and ren-

dered it possible for plants of a still higher order to grow, flourish and so on until perfect soils were produced in which all plants might luxuriate. **The making of our soils with their remnants of decayed vegetable and animal matter known as humus or mold, containing the soil organisms so important to the agriculturists, was a slow process covering many thousands of years, in fact the work of the ages. Yet it would take but a few short years to destroy this great reservoir of God-given fertility if no thought was given to return in a measure the great amount of fertility taken off each year in crops, straw, stover, etc. Therefore, soil protection and soil improvement are all important problems needing most careful attention.**

**The Virgin Soil.** When the soil came to us from the hand of nature it was open, arable—full of vegetable matter—resulting from the decay of leaves, twigs, trees and vegetable growths for centuries. After cutting away the timber and removing the roots, the soil broke easily and was made ready for planting or sowing seed, with little labor and the crops were easily cultivated and the roots of the growing corn were heroically pruned by deep plowing with single and double shovel plows but the soil conditions were so favorable that corn would make a vigorous growth notwithstanding the severing of half or more of the rootlets. When breaking the land it was a common remark to say "The dirt falls from the mole-board of the plow like an ashbank." The crop yield was not marvelous considering the soil conditions but very satisfactory indeed.

Our soils are not so arable now and not so productive or easily tilled, especially those that have not been brought up to the standard with ideal farm practice. Now our soils must be plowed and made ready for planting or sowing seed within three or four days after they become dry enough in the spring to plow. If we fail to improve the time named, then the land breaks up cloddy and requires repeated working and much labor to put it into a satisfactory condition.

The preparation of the soil and the cultivation of crops require much more labor now than was needful when the soil was fresh, open, porous and arable, and the yield of grain is not so satisfactory and our meadows and pasture lands do not grow such vigorous grasses as in the early days, on account of the want of better soil conditions and the decrease of fertility.

**The Decrease of Soil Fertility.** The decrease of our soil fertility is to be accounted for in many ways. The growing of crops and the selling of them by the bushel and ton off of land was indeed a selling of fertility. There was nothing thought of it for many years, in fact there was a general feeling of confidence in supposing that soil fertility could hardly be exhausted, at least

## MAKE-UP OF SOILS

Soil is made up of exceedingly small particles of irregular shapes, varying composition, and different properties.

It is formed by the breaking down of rocks, which are disintegrated by the weather, ground up and distributed by glacial action and floods, and mixed with the products of successive ages of vegetation.

These particles as they appear under the microscope are rough and irregular, some of them exceedingly small. As the soil particles cannot lie together so as to form a solid mass there is a large amount of intervening space, which in the average soils equals nearly half its volume.

## SURFACE TENSION

As a result of a force which is known as surface tension each particle of soil holds a film of water over its entire surface and thus provides a supply of moisture for the roots of the plant. When the quantity of water in the soil is so much greater than is required to supply that which is held by surface tension that the remaining space is filled, the soil is said to be saturated.

Provided with a tile outlet, this surplus water, or water of saturation will pass off by force of gravity, leaving only the film of moisture which is held by surface tension and which furnishes the required moisture for plant growth.

Fifteen to twenty per cent of all water which a soil will hold WILL NOT PASS OFF BY DRAINAGE but remains to contribute to the growth of the plants and to aid in the further preparation of additional plant food.—Western Tile Drainage Bureau.

not for two or three generatitons. They began to awaken when many of the farm lands were worn out and produced but little. The selling of our farm crops by the bushel or the ton without replacing any of the great amount of fertility taken away in this manner is not the only serious loss that is drawing heavily on our soil fertility.

**Surface Washing.** The surface washing of our cultivated lands is taking from the soil, vegetable matter, the fertility brought to the surface by the capillary action, the fertility brought down by the rainfalls and the fertility applied in part, from manures and fertilizers, together with the fine particles of the soil—all this is passing away in the muddy dark dyed water which runs into the little streams and on into the larger streams never to return.

The average farmer turns the soil about five inches in depth, plants, cultivates and gathers the crops and sells them, and leaves the land bare much of the year to be washed as before described, and the following year turns up the other side and does the same with it, and so on year after year for thirty or forty years. If the humus or vegetable matter and much of the fertility is not exhausted by this time, it must be extraordinary soil.

In view of this state of facts, is it any wonder that our soils do not plow and are not as easily tilled and do not yield as abundant crops as they did when they came to us from the hand of nature?

**Prevent Soil Erosion.** Statistics show that through the enormous waste of farm land occasioned by the action of erosion or soil washing that two per cent. of the entire main land of the United States has been devastated and that this total would mean 4,000,000 acres or nearly 100,000 crop-producing farms that have been destroyed. While the real time to prevent such disasters is before they start, a great service can be rendered by the farmers if they use and urge farm practices that will provide for the prevention of soil washing and this applies to both cultivated and uncultivated lands.

Many practical methods have been suggested by representative farmers such as the following:

1. Scattering a little straw in the furrow to catch the sediment and stop washing.

2. A liberal top-dressing of barnyard manure to not only build up fertility of the soil, but to help in holding sloping land when heavy rains fall.

3. All gutters to be filled in with straw, corn stalks, weeds or any kind of rubbish that can be gathered up on the farm.

4. Leave the fourth crop of alfalfa stand.

Land in bad condition, but a little work will establish pasturage.

## THE WASHED LANDS OF INDIANA

There are thousands of acres of land in Indiana which were once fairly productive, but which by reason of neglect have become badly eroded and practically worthless.

Some of the most important ways of preventing washing are strip farming, mulching the brow of the steep slopes, skip plowing, diverting the run-off, and keeping the land in permanent vegetation.

Some of the most evident means of recovering land that is badly washed is that of filling in with straw, corn stalks, weeds, brush, even tree tops, logs, and trees. These fillings will in a short time check and hold large quantities of silt and stop washing. The filling in process can be greatly hastened by plowing and scraping in the ridges, and the land can be put in use by sowing alfalfa and other hay and pasture plants, or the growing of wheat and corn.

Denuded surfaces can be reclaimed by liming and preparing the seed bed and sowing to grasses, particularly red top and Kentucky blue grass.—Purdue Agricultural Experiment Station, Circular 20.

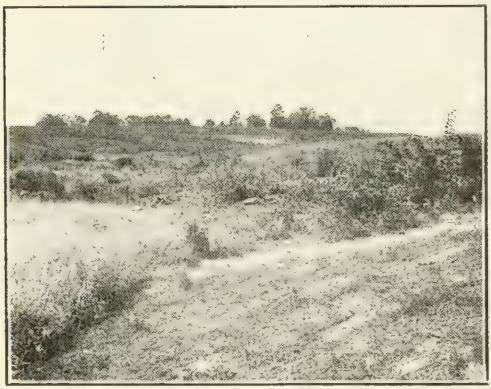
5. Sow rye and grass seeds in the washes, cover with straw and when this grows through it will form a matting that can not easily be washed out.

6. Fill up a gully or ditch when that gully or ditch first begins to start or wash by throwing in a forkful of straw or an armful of brush to stop the water cutting back or sidewise.

7. If the gullies are not too deep the banks may be plowed down, first filling with straw, brush, etc., to prevent future washing; then after the ditches are filled up and ground leveled the ground to be sown to some kind of grass that will produce good sod.

8. Plow the ground in beds or lands of not more than ten yards in width.

9. Driving a wagon across a muddy field or down a hillside



A Draw That Grew Weeds and Willows and Was a Source of Trouble.

Gathering Large Well-Filled Ears of Corn—60 Bushels to Acre on Former Draw.

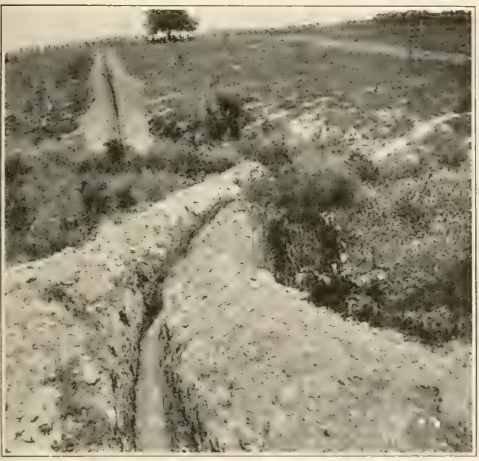
leaving wheel tracks starts soil washing. Take care of the wheel tracks or ruts by tossing in straw, brush etc.

10. Get the hill slopes in grass, meadows or pasture, and keep them under a covering of grass roots as long as possible.

11. Crop rotations should be so arranged as to keep the land in some growing crop practically the year round. Cultivated fields should be planted to something in the fall of the year that will tend to hold the soil during the winter and early spring when the most of the soil washing occurs. Either rye or vetch would be a good crop for this purpose.

12. Erosion can be controlled to some extent by the use of terraces, those used in this country are of two general classes, the bench terrace and the ridge terrace, each having variations which are adapted to particular conditions of topography and soil.

These suggestions are well worth considering and can be used with good effect, but the writer feels that the best method for the prevention of soil washing has not been mentioned in the above. As long as there is a surface run-off, you will have soil erosion. If your ground is dense and does not allow the water to go through, soil washing is bound to take place. This soil needs to be made porous and open and a means supplied, such as tile, to get rid of the surplus water. Tile underdrainage will not only prevent soil washing but increase the fertility of the land. If your soil is close grained, you will not raise the crops you should until you open it up and allow the fertilizing elements to go down into it. Tile underdrainage will make the hardest clay porous, will open it up and allow air circulation to greater depths. The water beating



Soil Washing Was Stopped and Production Increased by Tiling the Draw on Eby Farm.

Which Do You Prefer, the Good Crop of Corn or the Crop of Weeds? Drainage Pays.

down upon the land will sink into the soil, if the soil is open, and the tile drains will carry away the surplus thus giving the water some means of escape and preventing the surface washing. In getting rid of this surplus water, you are accomplishing another splendid thing, the water passing down through the soil to the drain tile will carry a great amount of nitrogen and fertilizing elements you would not get into your soil otherwise. If your land is properly underdrained, there will be no appreciable surface washing for the soil will take in the water like a dry sponge and the drains will carry it away. Hill-top farms naturally are more subject to erosion. Many farmers think a hill-top farm does not need tile underdrainage, believing that it has a natural drainage suitable for

all purposes. This is decidedly a mistaken idea. There is scarcely a farm in the state but needs some drainage. You can't drain too thoroughly. Hill-top farms, nine cases out of ten, will consist of hard clay soils. Here is where the greatest soil washing occurs. Make the soil less resisting, make it open to receive the rains and the snows and soil washing is prevented to a great extent.

A farmer in Fayette county, Ind., has been working wonders with worn-out cut-up lands, which a few years ago were not even fit to turn cattle on. The land was full of cuts and gullies, covered with rank patches of weeds, briers, bushes and wild growths, there being little or no grass. Mr. Eby, the gentleman referred to, is one of the large land owners of Fayette county. He is an energetic, hustling, up-to-date farmer, who carefully studies farm practices and is never afraid to go ahead with his projects once he is thoroughly convinced that his theories are sound. His lands in the north part of the county are excellent, but his Columbia township farm, the one we wish to tell about at this time, is composed of some very good farming land, but about half is rolling with almost steep hill-sides underlaid with a hard clay subsoil. Five years ago this clay land was unfit for farming or even pasturing.

It is one of Mr. Eby's delights to take this kind of land and make it produce. He took a section of similar land some years ago, thoroughly tiled it, opened up the soil, made it porous, got rid of a great deal of the soil washing and soon had this formerly dense, cold, clay, gullied land producing a fine crop of alfalfa. The land did not show much improvement the first year for it took considerable time to get the soil in a porous condition, but once this was accomplished, great improvements were made. Instead of rank growth of weeds, briers, etc., a thick bed of alfalfa covered the ground and a seemingly non-productive land was made into a money making field. Five years ago this land was worth about $10 an acre. After the improvements were put in, it was worth at least $75 an acre, while today, with its greatly added productivity, it is safe to say that Mr. Eby would not take $150 an acre.

The illustrations shown were taken during the late summer of 1916 of a new part of the Columbia township land which he turned into a field of alfalfa. Notice the deep cuts and gullies, the rank growth of weeds and barren spots; they show the non-productive condition of this land prior to making improvements.

Mr. Eby did extensive tiling on this land, using over 15,000 feet of 5-inch tile in 1916 and nearly that amount the year before. On the land tiled first he grew corn in 1916 which made a good yield, considering the bad season and condition of the soil. His crop yield the next season was much better. His tiling was paid for in full within a very short time and his production increased

as the soil was built up and enriched. The land he tiled in 1916 grew a fair crop in 1917, but the second crop was much better because at first the subsoil was so hard and had had little time to become porous.

Much comment has been made lately by quite a number of farmers on the splendid crops produced on Fayette county rolling land, some of which would not bring as much per acre by $50 or $75 as good black Rush county land, but produced a crop of corn last year equally as good and in some cases even better than the higher priced lands. This is good evidence that rolling land, where soil washing has been a big problem is a sure crop producer when it is well underdrained.

Tile underdrainage is a splendid prevention of soil washing and should be the real basis of any work to save the land from the great waste of erosion. Of course tile underdrainage cannot in all cases absolutely prevent soil washing for there are places in the land which need abutments, filling or the sowing of grass or some crop to hold the soil in place.

Hill-top farming should really be devoted to the growing of the smaller grains, these preventing soil washing in the main. The twelve suggestions referred to in the first part of this subject are well made and should be used wherever possible to prevent soil washing, but tile underdrainage should be first considered.

The Eby land, before being improved, was a source of expense to him, he receiving no income whatever from it. This land, although hilly, had mossy growths and patches of red sorrel indicative of a sour condition. Indiana has thousands of acres of just such hill-top or rolling lands where soil-washing is taking away constantly the richest part of the soil. This soil washing could be eliminated and good crops produced if the land were thoroughly tile underdrained and the suggestions made above followed where applicable.

Scores of similar examples could be pointed out in these pages (in truth this big factor tile underdrainage which is the best investment the farmer can make, is truly the real foundation for successful profitable farming) but there is so much more to tell about underdrainage later on in this book that the writer feels that but two other examples which are well worth the reader's careful study will suffice on surface washing.

**Stops Soil Erosion and Makes Over Worn Out Soil.** Fourteen years ago George and Herman Walthers, who formerly farmed in Ohio, purchased the old Colescott farm, located on Mt. Carmel Hill near Brookville, Franklin County, Indiana. This is hill-top land in one of the finest scenic sections of Hoosierdom.

For more than forty years this farm had been worked with variative failure. The land consisted of cold clay soil on top of a hill regarded by farmers of the community as having all the drainage necessary. The land was obtained from the government 100 years ago by Colescott. It was heavily timbered then. The clearing of the land was the real basis of prosperity in those days. After the timber was removed, forty years ago the farmers turned to cultivating the soil. It was planted in wheat and corn year after year with indifferent success and changed ownership several times, each purchaser attempting to cultivate the soil into fertile condition without success for the ground was dense, badly eroded and worn out and the rains washed the fertilizers into the gulleys and wore cuts into the hillsides that made farming difficult.

The land produced at best thirty bushels of corn or twelve bushels of wheat to the acre and not a very good quality of crop at that. So when the Walther boys, stock buyers, bought this depleted farm for $48 an acre and said they were going to underdrain it thoroughly, the farmers thereabouts said they were crazy and headed straight for the poorhouse. All this ridicule did not bother the Walther brothers, however, for they were working on a theory they thoroughly believed in.

They bought the old Colescott farm of 160 acres and also a 100-acre tract of land adjoining. At this time, fourteen years ago, only fifty acres were in cultivation on the old farm, the rest being covered with weeds or briars, and the fences were in a dilapidated condition.

The Walther brothers, being thoroughly experienced in stock and trading and having gained a good farming knowledge on a farm in Ohio, decided they could make a great deal more money by stocking a farm with the best feeding stock and preparing the stock for the market, than they could by straight buying and selling. With the idea of running a feed and stock farm they immediately began to prepare their newly bought land paying little heed to the well meant advice of the neighboring farmers.

**Yield More Than Trebled.**

The first year they built a suitable road up to the farm and fenced the entire property. Five men were employed constantly the first two years ditching the land, hauling, putting in clay drain tile and filling in the gulleys. A barn was built and the farm straightened up in general. By the end of the second year eight miles of tile drains had been laid and a great improvement in production of crops was at once noticed. Every year more tile drains were put in until today more than fourteen miles of clay drain tile are in use on this farm. Each succeeding year there has been an improvement in the crops until today this farm is producing from eighty to 100 bushels of corn to the acre, where formerly it produced only thirty bushels and forty bushels of wheat

against the twelve bushels to the acre before the farm was tile-drained. In 1917 they had the record yields of 110 bushels of corn and 53 bushels of wheat to the acre.

Every farmer who had regarded the Walther brothers as wild in their scheme and had said the land had all the natural drainage necessary are now strong in their praises and are turning their attention to underdraining their land.

This cold clay land was so dense and close grained the water could not get into the soil and all the fertilizers placed there produced no good result, for the ingredients needed could not get down into the soil and were washed away into the gullies without serving any purpose. The soil being dense the air was not permitted to circulate in it and the needed nitrogen could not get to the plant roots. The growth, therefore, was stunted and a poor crop resulted. The plants could not reach out for the food they needed and there was not sufficient air. A plant will not thrive in a cramped place. It needs plenty of air and, like humans, can not be healthy with "wet feet."

**A No. 1 Land Now** The Walther brothers knew the needs for good plant growth, studied the conditions of the soil near Brookville and did the only thing possible to open it up, make it porous and prepare the way for enriching it. The land on this farm is A No. 1 now. Tile drainage did the trick. The subsoil was broken up, the pore spaces were enlarged, thus permitting the water to go into the ground and the excess water to pass off through the drains. The water passing into the soil took with it the fertilizing elements needed and the soil was thus enriched. The air entered the pore spaces and circulated in the soil, giving the plant a goodly quantity of nitrogen. The soil being rid of its denseness, the plant roots went deeper into the ground in search of the plant food needed . The soil became warm, thawed qûickly in the spring, was easier prepared and gave a month's longer season, so the crop was well in hand before the frost came.

The second year after the first lot of tiles was put in, the profits were more than sufficient to pay for the tiling. At first, clover, corn and wheat were grown with great success. The second year, part of the land was put to alfalfa, sowed broadcast. There wasn't a good stand, so it was plowed under, and the ground limed and then seeded. This resulted in as fine a crop of alfalfa as could be made. The soil needed lime rock.

**Fine Alfalfa Now Grown.** The Walther brothers were ridiculed when they made known the fact that they intended to raise alfalfa on their farm. The farmers declared that alfalfa could not be grown in that kind of soil, but soon they saw the fallacy of their belief and were not slow in taking advantage of the example

set. Some of the finest alfalfa in the state is grown in Franklin county today. One farmer, last summer, obtained more than six tons of alfalfa to the acre.

The Walther farm has twenty-six acres of alfalfa, which is cut three or four times a season. After the crop is removed, a disc harrow is run over the ground when found convenient. Seven years ago there was an unusually wet season, and crab grass got started in the alfalfa, but this was killed out by running the disc both ways. The alfalfa does not require reseeding, it grows year after year, improving in quality. There is no expense necessary, except for liming.

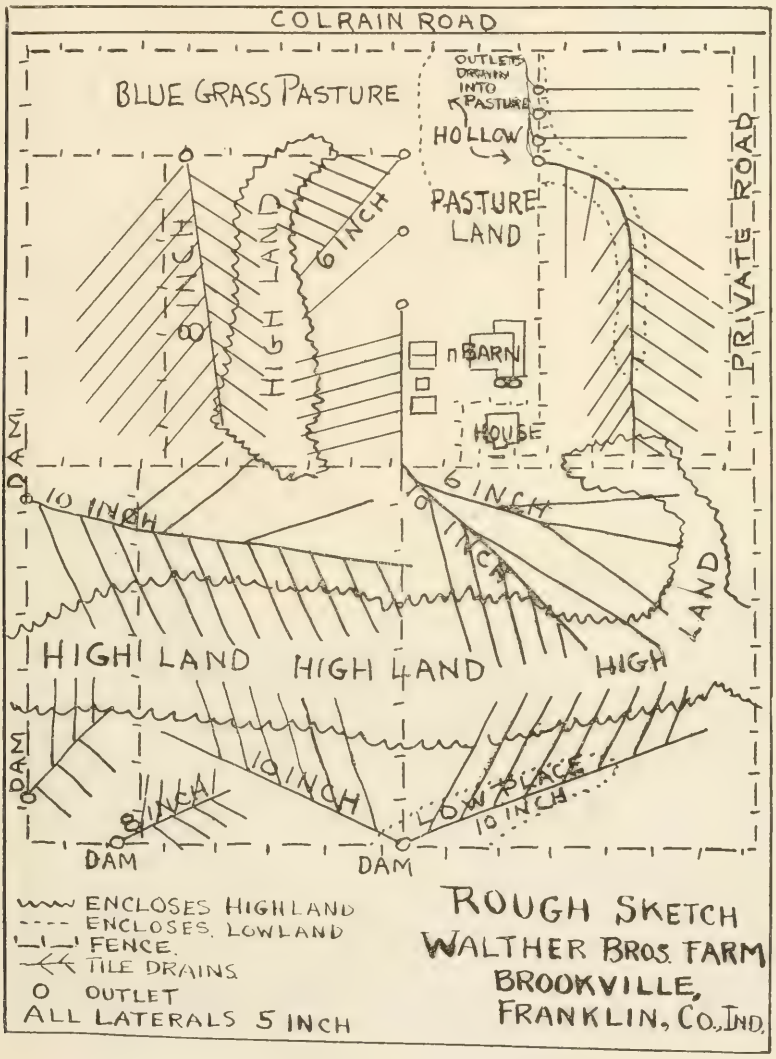
Sixty of the 260 acres in the farm are in clover. Last season

110 Bushels Corn and Large Crop Soy Beans on Land Formerly Badly Eroded.

there was a good stand. Herman Walther declared this was the best clover he ever saw. He also said he noticed that where they had grown corn and soy beans the year before, the clover looked much better, stronger and healthier. He attributes the good growth principally, however, to the tile underdrainage and manure combined. Every inch of the corn ground is covered with manure each year.

**Rough Sketch of the Farm.** The rough sketch of the farm shows the fences, tile drains, roads and location of the house, barn, etc. This is not accurately drawn to scale, for there were no blue prints or drawings to be obtained. The sketch was made

from rough outlines made while in conversation with the Walther brothers. The corrugated lines used to indicate the boundaries of the high ground on the farm were drawn to give an idea of the slope of the land and the need for placing the tile drains in the man-




ner laid. The borders of the prominent hollows are indicated by dotted lines. The drains are shown by straight lines, those not marked being of five-inch tile, the smallest tile used on this farm.

All tiles were laid thirty to thirty-two inches deep, there gen-

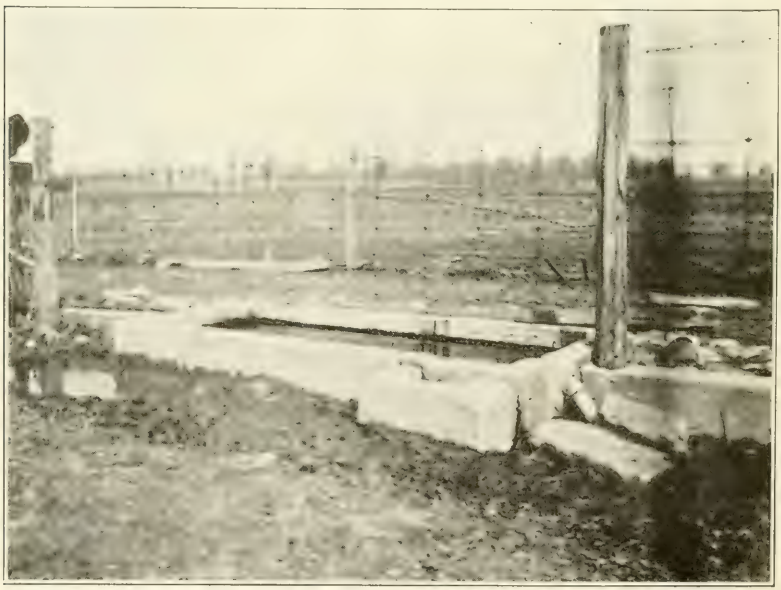
erally being a fall of one foot to 100 feet in the lines. In some places the fall is much greater than this. The outlets are indicated by circles. The southwest section of the farm has the deepest hollow The water from the drains on this part of the farm empties into the pasture land which is fenced in. Sections in rotation to the west of the pasture are put in corn and soy beans every year and "hogged off," forty acres of corn being required to fill the ten large silos There is a blue grass pasture in the southeast corner of the farm.

The twenty-six acres of alfalfa are along the eastern side. There are two fields of fifty acres each and one of thirty-five acres planted in corn, wheat and clover and rotated yearly.

The first cost of this farm was $48 an acre. The Walther boys today would not sell this farm for $200 an acre.

**Another Example** Hiatt Frost, one of the most successful farmers in Indiana, so well known for his farming knowledge, through his writings, addresses and real work on his two fine farms near Connersville, Ind., that Governor McCrea appointed him one of a commission of three to recodify our drainage laws, in a recent interview stated:

"Having in the past twenty-five years constructed some fifteen



Tile Fed Trough From Big Spring 40 Rods Away. The Overflow From This Is Taken on Through Tile Drain to Another Trough

miles of tile drains, largely on what is called semi-dry, rolling lands, I have been so impressed with my success in draining all but sandy or gravelly lands that I am ready to subscribe to the slogan, "More Tile Drains, More Net Gains."

"Underdrainage supplemented by a regular rotation in which the largest possible amount of humus is kept in the soil, not allowed to remain bare through the winter, practically stops erosion and gullying. The land is soon dried on top and quickly and early in the season relieved of the nuisance water down to the full tile depth, wet places are tapped by such tiling along with the drier portions, larger and more vigorous plant roots are invited and even forced to bore deeper and later decay and make an enlarged stratum of humus, and deeper breaking is encouraged and made possible; whereby the water reservoir or intake capacity is easily doubled and erosion is correspondingly diminished.

Crop production is increased because the plant food reservoir is much enlarged by the early lowering of the water level. Plant growth is better able to withstand drouths because of the deeper rooting and the taking of more water down into the lower reservoir therefrom the more abundantly later to supply the plant roots by capillarity. There also results better sub-soiling from the deeper and

Second Trough Receiving Water Overflow From First Trough and Drainage Water Collected From Main and Lateral Drains.

more vigorous plant rooting and increase in porosity of the soil, whereby more air is let into it, thus both unlocking plant food and sweetening the soil.

By taking in more of the nitrogen-charged rain and snow water that costly plant food element is correspondingly increased in the soil. The soil is also given additional warmth in the spring at which time the rains are warmer than the soil and the soil made drier by this sub-drainage, takes in more sun-warmth, thaws out more quickly and warms up earlier, the cooling process of evaporation is checked and the soil thus made drier neither freezes so deeply nor so unresistingly. Such conditions practically make our heavy clay lands as warm and dry as our more porous bottom lands with gravelly subsoil. These clay lands thus warmed and dried allow much earlier planting as well as earlier breaking and quicker and more effective and easier working, thereby conserving horsepower. Thus we make our heavy clay lands quite the equal in warmth and earliness of our more porous bottom lands while they still have the towering advantage of a practical reliable supply of capillary moisture to draw from through the dry part of the growing season.

Many of these apparently small items that we have thought but little of soon aggregate into the one big item of less erosion, larger crops and added permanent value to our cultivated lands.

No little advantage will result from increased water supply for stock by reason of many instances of carrying water down into a

Outlet to Drainage System and Overflow From Two Watering Troughs.

lower field and in other cases by giving a constancy to the water supply at the tile outlet from tapping springy and sprouty sections of the soil.

I have often wondered how many landowners have taken advantage of the drains to put stock-watering places down below in other fields, where before there were only water and mud holes a few months each year, by tapping springs, seepy spots and hog wallows and thereby securing an almost constant supply of clear, clean water. The accompanying illustration shows the system on one of my farms, there is rarely a year with a month of water shortage, and where before there was a mud-hole supply not three months per year.

We have lands with tiled-outlet runs through them that are over a deep gravelly subsoil, lands where probably there is little excess water at any time; land, too, where there is considerable run-off, lands tiled only 20 feet apart and lands where topography and soil character are just the same over the tile as 4 or 5 rods away, and I have observed the growths of both deep and shallow-rooted plants directly over these tiles and as far as five rods away, and in the driest season in the first year's growth of clover when roots are only slightly developed and even when the season was so dry as to kill out the clover in spots this, remember, before the roots had had time to establish themselves deep down toward the more permanent mois-

Hogs Play Havoc With Outlets—See They Are Hog Proof.

ture supply—and I have never been able to observe but what the plant growth seemed always as good, and in many cases apparently better, over and nearer the tile than several rods away, on exactly the same topography and character of soil. When the full rooting has developed, it is perceptibly better over than far from the tile, generally. So no more worry for me that I may on any kind of soil and in the dryest season overdo this tile drainage. This can be accounted for in part, by reason of more water getting down into the soil below the tile line.

Tile drainage not only will increase the productiveness of these so-called fairly dry lands very materially indeed, but in case of classes of cold, backward, but level lands in this state, the production will easily be doubled. By reason of this increased crop production and the checking of erosion, the permanent value of our hilly or rolling and washy lands on an average will also be doubled."

We know that the water from tile in perfect working order and having no in-take is always clear as spring water—there is no erosion therefrom—while the run-off "over the top" of the soil is roily—badly discolored with soil particles in suspension.

Do we fully realize what tile drainage has already done for us in Indiana in reclaiming wet lands? Systematic drainage of our so-called dry lands in connection with the wet spots therein will aggregate even more benefit.

Many farms in Indiana now have two, three or four acres of their best land in draws and depressions that the plow has never touched that would repay the entire cost of drainage the first two years. In contemplating work of this kind, you should lay out and prepare for a system, though for the present you are only draining a draw. Make as few outlets as possible, the mains deep and outlet absolutely hog proof, with a generous cement header. Hogs are the greatest menace to tile outlets as well as to wrongly located tile in springy places. Always cut in higher up, not below, springs, stop all swirl-holes at once, cement the junctions, close up dead ends effectually, lay tile so as to leave the closest possible joints, cement all open joints in large tile cut across occasionally and not follow gully-channels, kill out all bush and tree growths near tile that has constant flowing water use a five-inch tile or larger laterals on flat ground, four-inch laterals are ample where there is a good fall, and make permanent in-takes of cement, and by such construction and maintenance, make your drainage practically everlasting.

In a broader view complete tile drainage of practically all of our cultivated lands would prove a national benefit in largely restoring pioneer conditions to our prairie and forest lands by reducing soil erosions, and by giving constancy to streams, lengthen river navigation, minimize floods and almost double water power; and for

these reasons the state and national government should foster such drainage as a conservation move, of world-wide value."

**Adding Humus** It should be the leading thought in the management of the farm, to get all the vegetable matter which is reasonably available into the soil. It is not only so much more added fertility, and the store-house of the needed moisture, but it so greatly improves the mechanical condition of the soil, that it is easily plowed and tilled, and promotes a more vigorous growth of farm crops and greater yield and better quality of products.

Straw, stalks and vegetable matter of all kinds, which would otherwise be lost, should be turned into the soil, together with an occasional green crop. "More Humus—More Humus," should be the watch-word on the farm. Plan to do this more and more, do not consider it a loss, but rather a deposit in the bank to be drawn upon in crop growing. The burning of straw, cornstalks and other vegetable matter which would serve to make up some of the loss occasioned by surface washing, is a serious waste. Again and again we have seen stubble fields, the aftermath of meadows and litter of all kinds, burned to avoid turning it under, which would add to fertility and better soil conditions.

**How to Increase Soil Fertility.** At the base for increasing and maintaining the best soil fertility, is underdrainage, where the soil needs it, and most clay soils do need this important improvement. In fact nearly all of our soils in Indiana need to be underdrained. Underdrainage, deepens the soil—in our drift clays we may have a depth of soil as deep as we drain—if the tile are laid well at a depth of four or five feet, the soil will become open and porous in the run of a few years, as deep as the tile are laid. The roots of the most of our farm crops will penetrate as deep as possible in quest of plant food and moisture. Practically, our crops will be drawing their food and moisture from a farm underneath our farm.

Thorough underdrainage serves to conserve moisture in the soil for the use of farm crops—by condensing moisture from the air and holding it for the use of the crops—by condensing, we mean that the air in circulating through an open soil at the depth named above, comes in contact with the cooler earth and the moisture forms on the particles of soil the same as dew on vegetation. In time of extreme drouths, deeply underdrained land will be found moist a foot or so below the surface and the growing crops will show but little damage from the drouth.

The circulation of the air through the drained soil effects chemical changes of much importance in the preparation of the plant food. There is a vast store of fertility deep in the earth but for want of air it is in an insoluble condition, the plants cannot use it until the

air, heat and moisture make it soluble and available as plant food and underdrainage brings this about, thus adding to the available fertility of the soil.

Underdrainage also makes the manures and fertilizers applied to the soil contribute more freely to the betterment of the soil by taking the liquids into the soil, and also prevents largely, the surface washing, by which such vast stores of fertility are lost never to return.

**Saving and Applying Manures.** An important feature in the increase of fertility is the saving of manures—plan to save them and apply them in the most beneficial manner. Shedded barn lots and shelters to cover manures until they are spread on the land will add much to the quality saved and the better fertility.

**Crop Rotation** Each crop grown on the farm draws upon the needed supply of plant food in the soil. Hence if one kind of crop is grown for a long time upon the same piece of land, the soil at length becomes exhausted of those kinds of plant foods upon which that crop feeds.

The benefit of crop rotation may be briefly summarized as follows:

First. It economizes the natural supplies of fertility contained in the soil.

Second. It economizes applied manures by making use in due time of all their fertilizing ingredients.

Third. It tends to the enrichment of the surface soil in that some plants, for example, beans, peas, etc., draw large supplies of plant food from the air and others as clovers, draw their food deep down in the sub-soil. Then the rootlets decay and add to the fertility and better soil conditions mechanically. Other crops may draw their food supply from nearer the surface of the soil and then the rootlets decay and thus equalize the benefits to the different depths of soil.

The following rotation finds favor with most successful farmers: Corn, wheat and clover. Other rotations may be better suited to the conditions of the soil, climate and market. We insist that as a rule crop rotation adapted to the existing conditions will aid much in increasing the fertility of the soil. In this connection, let us take into consideration the

**Deeper Plowing Better Tillage.** If something like a uniform depth has been followed in the breaking of the land for years and the sub-soil is possessed of more or less fertility, though in an insoluble condition, deeper breaking should be done, but the increase in depth should be gradual from year to year. The sub-soil

should be brought to the surface in small quantities at a time. As a rule it is better to plow deeper in the Autumn than in the Spring, for the reason that the weather during the winter will have a beneficial effect upon the new soil. It is better to sow some kind of cover crop in the fall, to prevent washing and to work into the soil in the Spring.

The preparation of the soil should be thorough before planting—the better the seed bed the better the crop. The cultivation of the crop should be frequent as the needs of the soil may indicate—keep in mind that the stirring of the soil is to give a circulation of air through it, to aid in making the fertility available to the plant growth and to prevent the escape of moisture at the surface, where evaporation takes place.

Each rainfall will likely cause crust to form on the surface; this should be broken as soon as the soil is dry enough to stir, and the surface should be made fine and mellow or mulched as it is commonly expressed. Avoid root pruning, or the breaking of the fibrous roots as much as possible, continue to cultivate as long as the stirring of the soil will promote the growth and the further development of the crop products.

**Growing Clover and Other Legume Crops**

This is an important factor in the increase of soil fertility. In the crop rotation clover should be included. It is a deep feeder, having a tap root that is often found at a depth of three or four feet. This plant has the power of bringing fertility up to the surface and in addition the power to take free nitgroen from the air, through the nodules or bacteria on the roots. The same is true of other legume plants, such as beans, peas, vetches, etc. The turning of a crop of green clover or cow peas or soy beans into the soil will increase the humus and at the same time add to the fertility and aid nitrification, in preparing plant food.

My grandfather, J. J. W. Billingsley, was an authority on many agronomical subjects and his notebook containing his lectures is one of my proud possessions. On the subject of "Growing Clover on the Farm," he wrote (in part), as follows:

"In the year 1864, the writer purchased a well worn farm, and wishing to increase the fertility, I sowed over 100 acres of the land in wheat, intending to seed it afterwards to clover and did so. One field in particular was much poorer than the others although all of the land was originally good, but fifty years of crop production and washing of the surface, with no return of fertility had pretty well used up all the fertility near the surface. The average yield of wheat on the field in question was nine bushels, the stand of clover secured was fairly good, and made a good growth after the wheat was cut.

## WET FIELDS ARE WASTE LAND.

Drowned out, burned out Indiana oat field. This undrained field stays wet a long time in the spring; is swampy and soggy after rains and gets hard as bricks in dry weather. The crops are small, late and patchy, sometimes not at all.

Wheat, over the fence trying to grow in a water-logged field. It is winter killed or frozen out in spots and all of it crippled by heaving. These flat, wet fields will never grow winter wheat, clover or alfalfa with certainty until they are drained.

It is one big job of waste trying to grow corn or any other crop on a wet spot. Wet fields have time, labor and fertilizer spent on them which are always partially, sometimes totally lost.

There is no more discouraging task on earth than undertaking to grow crops on fields like these. They can be drained and made productive and profitable where now they are a loss, an aggravation and an eyesore.—Courtesy International Harvester Co.

The season following, the clover was allowed to grow until full head and then some cattle were turned on it, and allowed to graze two weeks or more, tramping the clover down. The cattle were then turned off and the second growth of clover came on and when at the point of maturing the seed, the clover was turned under, which included much of the first growth, as well as the second.

"The land was then seeded to wheat and made a yield of 27 bushels, and was seeded to clover again and then to wheat, which yielded 31 bushels to the acre and was cropped for years with a crop rotation of corn, wheat and clover, growing good crops.

"By using clover in the crop rotation indicated on other fields the same gratifying results were secured. It was not long until many other people judged the farm to be the most productive in that section of the country. This is not theory but just what I have done and what any of you can do and what many of you possibly have done.

"When the land is new and full of vegetable matter it is comparatively easy to get a stand by sowing the seed on wheat, the last of February or in March, when the surface is heaved up by frost, sowing about one bushel of good seed on eight acres.

"After the land has been in cultivation forty or fifty years the crops taken off, and the land pastured bare, and then washed by the rainfalls from year to year, it is difficult to get a stand of clover. I have succeeded in getting a stand fairly well by waiting until about the first of April or until the soil will pulverize a little, then go over the field with a fine tooth smoothing harrow, making a little mulch on the surface. It was necessary to weight the harrow a little to do good work. I then sowed the seed both ways, with a wheel barrel seeder and in this way got a uniform stand. After sowing the seed, I went over the field lightly again with the harrow. I have not failed to get a stand in this way of seeding. After the fly put in an appearance I have not grown any wheat but have succeeded quite as well in getting a stand of clover, sowing with oats as follows: I prepare the land well by breaking, disking and harrowing. Then drill in the oats one bushel or at most a bushel and one peck to the acre, and then sow one bushel of clover seed to six acres, sowing both ways, about one-half of the seed at each time going over the ground, and then go over the ground with a light smoothing harrow or better, a Breeds weeder. In this way I have succeeded in getting a good stand of clover. The oats are sowed thin to let the sun shine down through the oats on the clover to harden it. The oats being thin on the ground, do not draw so heavily upon the moisture in the soil, which is especially true when the oats come to ripen up, and are heavy, they leave little moisture in the soil for the clover after the oats are cut and heavy oats shade the clover

and make it tender and the soil left dry by the ripening of the oats, the plants perish.

"With thin sowing of the oats and careful seeding of the clover we get a good stand and a fair crop of oats. The thin sowing of the oats will grow larger heads and a better grain and make a fair yield. If the land is comparatively free from weed seeds and well prepared for seeding a good stand of clover may be secured by sowing clover without any nurse crop.

"After cutting the wheat or the oats and the clover grows up to be ten inches or a foot high, run the mower over it, setting the bar as much as four inches high to cut the clover and stubble and the cuttings drop down on the ground it will add to the fertility of the soil and cover the ground and make the clover grow better. If the season is favorable for growth, it will need to be cut again not later than September 15th. Do not pasture young clover, if so, the loss will be heavy in the future of the crop and to the fertility of the soil.

"In the selection of the seed be sure to get round plump seed the very best the market affords, free from weed seeds and faulty seeds. The good seeds will germinate and grow a strong, vigorous plant and the poorer seed will have many seed that will not germinate and the seeds that do grow may grow weakly plants, besides the weed seeds are likely to introduce pests, that are not easily exterminated.

"Prepare the soil well, sow only good seed and sow evenly and afterward cover lightly and there will be little trouble about getting a good stand.

**Kinds of Clover.** "My experience in growing clover has been limited to growing what is commonly known as red clover, with two exceptions. Red clover has apparently met all the demands which have been made upon it. For grazing stock, for hay, seed and fertilizer power, live stock of all kinds do well when turned to clover with care and a little salt. The hay when well cured is excellent and the seed crop, we have all heard, depends on the 'bumble bee.'

"Mammoth clover is more rank in its growth, shades the land better, perhaps matures a few days later, it is claimed, but makes a poor hay, and matures its seed in the first and only cutting for the season.

"Alsike clover is said to be especially adapted to wet land, or to overflow bottoms. Alsike will grow on land too wet to plow and it is claimed that it will aid in the drying up such land. It is said to make good pasture and an excellent quality of hay. It is further claimed that it will survive the severest cold without winter killing.

Red clover is the most practical legume for ordinary farm use in Indiana

The successful growth of clover or other leguminous crops is an essential factor in maintaining the fertility of most Indiana soils. Legumes are soil renovators in a marked degree and may be very profitably employed in building up run-down soils. Without legumes, the problems of maintaining adequate supplies of organic matter and nitrogen in soils are difficult; with legumes, they are simple.

To produce maximum crops, the ordinary soils of the State should bear clover or some other legume at least once every three or four years and most of the produce should go back to the land in one form or another. In a rotation of corn, wheat and clover, averaging 60 bushels of corn, 25 bushels of wheat and two tons of clover hay to the acre, where the corn stalks and second growth clover are left on the ground, the wheat grain sold, the ear corn, clover hay and wheat straw utilized as feed and bedding and the manure carefully saved and returned to the land, the nitrogen balance in the soil will be just about maintained.—Purdue University Agricultural Experiment Station.

"Alfalfa, according to a large number of successful farmers, is ranked in first place in the clover family."

**More Land to Grass.** As a rule, we have too much land in cultivation, too much in corn, especially those who are cultivating 45 or 60 acres in corn, might do quite as well to put their thought and labor on half that area with quite as good results in the amount of the product grown, and the fertility of the soil, and turn the other half to clover, red or alfalfa, and blue grass. By so doing they could rapidly increase the fertility and make quite as much money.

**More Live Stock.** You can turn your farm crops into beef, pork, mutton, wool, milk and butter for market, if you keep livestock. In selling such products you would sell the least possible fertility, and have the means at hand of returning to the soil more than you take from it in the way of fertility.

Mr. Walthers, of Brookville, Ind., in a conversation with the writer, made the following statement which is apropos at this point

"The farmer nowadays who farms simply for the crops never gets rich. Feed and stock farming is the thing, for through the stock you secure the manure for enriching your land which will make your crops larger and better and they in turn make for better cattle and stock bringing the topnotch figures."

The Walther brothers buy in the spring, summer and fall, when they find good feeding steers or calves, and take them to the farm, where they fatten them up for the market. Large profits are made in this way. They are now raising 250 hogs, 200 ewes, more than 100 lambs and 172 cattle. The feeding capacity of their barns is 350 head of cattle. They aim to put in about eighty to ninety-pound shoats. The shoats follow the cattle. When they begin to ship the cattle they feed the hogs lightly and then after the cattle are gone they give the hogs forty days of good feeding. The hogs are fed on corn and feed tankage.

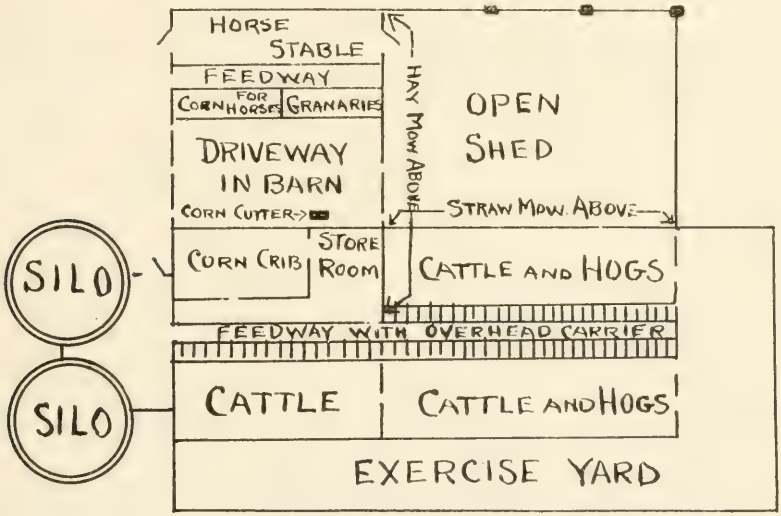
The sheep are fed on ensilage, clover, hay, oats and corn. After the ewes have lambs they begin to feed them the grain. The cattle are fed on ensilage and cotton seed meal and corn, and after this is cleaned up they get clover and alfalfa hay.

The brothers have not had any trouble with cholera and have not vaccinated any hogs in five years. It is all in the method of taking care of them, they say.

The cattle are taken out to water in a concrete paved yard just outside the cattle barn and permitted to stay there for two hours. There is a central feed-way running the length of the cattle barn in direct line with two large silos at the west end of this 102x42-foot

structure. An overhead carrier system conveys the car of ensilage or feed to the point desired. The accompanying floor plan of the barn shows clearly the arrangement.

**Barn Is Well Arranged.** One of the leading men of the agricultural department of Purdue University, after inspecting this barn with a class of students, declared that it was the handiest, yet inexpensive, barn he had ever seen. It has an ideal arrangement; there are no retracing of steps, no lost motion. The materials are handled in direct lines and every foot of space is accounted for. The two silos at the north end of the barn have a capacity of 140 tons each. The overhead track and carrier leads




Plan of Walther Bros. Barn.

directly to the doors of the silos, so the carrier may be filled with ensilage or a feed from the stockroom as is desired and the stock fed at any point along the 102 feet of track. On the west of the feedway are hay racks extending the entire length, while on the east is the same arrangement from the south of the barn to the storeroom.

Above the spaces where the cattle and hogs are bedded is a straw mow. The straw is blown in through a door on the east side at the time of threshing, doing away with straw stacks and the loss incident to stacking. When the cattle are turned out to water and exercise fresh straw is thrown down from the mow and spread over the accumulated manure. When the doors are opened again for the cattle to return much laughter is provoked by the way they kick up their hoofs and frisk about in the clean straw. The hogs are permitted

to run wild in these spaces and out into the open shed where ears of corn are tossed to them from time to time.

**Corn Cutter Is Used.** The corn crib is in the central north part of the barn in the storeroom. This crib holds 5,000 bushels. A corn cutter is stationed adjacent to it in the driveway of the barn. This machine cuts 100 bushels an hour. The driveway is wide and gives ample room for bringing in the loads of hay, corn, etc. A large track and hay fork with automatic trip is used in filling the mows on either side of this driveway. There is not a beam in either mow, the roof being self-supporting and thirty-two feet from the main floor to the center. The mows have a capacity of 150 tons.

On the east side of the driveway are the granaries and the storeroom for corn for the horses which are housed a few feet away, the horse stable and granaries being separated by a feedway.

## INDIANA SOILS NEED PHOSPHATES

Indiana soils are notably deficient in phosphorus

Available phosphates are the most profitable fertilizers.

Acid phosphate has given the best results.

Basic slag and steamed bone meal have also given good results, standing next to acid phosphate in profitableness.

Rock phosphate has given good results in certain cases, although it has been the least profitable of any of the phosphates used.

In immediate returns on the first and second crops after application, acid phosphate has yielded crop increases from three to over 25 times as large as those secured from rock phosphate.

Neither acid phosphate nor any other phosphate will increase soil acidity or the need for liming, although soils needing phosphorus generally also need lime.

Neither acid phosphate nor any other phosphate will injure the physical condition of the soil if due care is exercised to maintain the organic matter supply.

The only means by which the phosphorus deficiency can be made up is by the purchase and application of phosphatic fertilizers. Fortunately phosphatic fertilizer materials are plentiful in this country and relatively cheap.

Near the barn is a pumphouse with a gasoline engine and pump below the ground level, so there is never any danger of freezing.

On the east of the court surrounding the barn are the sheep barn, toolhouse and wagon shed. A brick house stands to the north.

**Making Best Use of Commercial Fertilizers.** Under this caption Prof. G. I. Christie, of the Experiment Station, Purdue University, gave some valuable information in the Indiana Farmers' Guide of Nov. 5th, 1921. In part it was as follows:

"* * * Fertilizers are bought for the plant foods,—the nitrogen, the phosphoric acid and the potash, that they contain. The mere price per ton means nothing unless the percentages of the various plant foods are known and considered. The desire of many farmers to secure cheap fertilizer is largely responsible for many low analysis brands that have been put on the market. Such fertilizers are undesirable in every way. Fortunately most manufacturers are willing, in fact anxious, to stop selling low-analysis goods, thus giving the farmer more for his money and at the same time making more money for themselves. The saving in freight, in bags, in storage space, and

## RECOMMENDATIONS

1. Adopt a systematic rotation of crops, including clover or some other legume at least once every three or four years.

2. Wherever clover fails to do well, apply two or more tons of ground limestone to the acre.

3. See that the land is properly drained and practice good tillage methods.

4. Feed as much of the produce as possible and carefully conserve and return to the land the manure produced, as well as any unused crop residues.

5. Apply from 150 to 200 pounds per acre of acid phosphate or some other available phosphate to each grain crops in the rotation. In a permanent system, where manure is applied for corn, enough phosphate for the whole rotation may be most conveniently applied when seeding wheat or oats. Under certain systems of farming, where the crops are not all fed on the farm, it will pay, under normal conditions, to add some nitrogen and potash in the fertilizer.

6. If acid phosphate or other available phosphate cannot be secured, a mixed fertilizer as high as possible is available phosphoric acid should be used.—Purdue University Agricultural Experiment Station.

in handling will be large both to the manufacturer and to the farmer. * * * The state chemist estimates that if Indiana farmers will buy only high-grade fertilizers they can save themselves $1,000,000 a year. Surely this problem is worth some careful thought and figuring. The results of inspection the past year show that 23,439 more tons of high-grade and 34,792 less tons of low-grade fertilizers were bought in 1920 than in 1919. * * *

The quality of the nitrogen or ammonia in fertilizers is now receiving considerable attention from the state chemist. Here, again, the advantage of buying high-analysis formulas is shown, for when the per cent of ammonia is low there is a greater likelihood of its being derived from low-grade materials and, therefore, less available than when the ammonia content is higher, let us say, 2 per cent or more. Fertilizers containing a small amount of ammonia, for example, one-half per cent or 1 per cent, may be made from the very best materials but this is frequently not the case. So when you buy fertilizers containing ammonia, the safest plan is to select one that contains at least 2 per cent of ammonia which is the same as 1.6 per cent of nitrogen.

Perhaps the biggest step forward in the direction of better fertilizers for Indiana was made when the Purdue soils and crops department published its list of standard fertilizer formulas for Indiana. Our investigations reported in previous articles show that about a dozen different formulas will meet all the fertilizer needs of our principal crops and soils. These formulas have been selected as the result of many years of experimenting with all kinds of fertilizers under all sorts of conditions. They are based on the composition of the soil, the needs of the particular crop and the practice in regard to the use of manure and the growing of legumes. These approved formulas are given in full on page 37.

Now suppose you have a light-colored clay loam soil and that you grow clover in a rotation with corn and wheat. We will assume that you use all the manure produced on the corn ground and that you have enough to cover about half the corn acreage. What fertilizer should you use? The answer from the table would be an 0-12-4 on corn without manure, and 16 per cent acid phosphate with manure. For wheat the recommendation would be a 2-12-2 complete fertilizer. (In the fertilizer formula the first figure refers to nitrogen, the second to phosphoric acid, the third to potash.)

Having determined the right fertilizer to use, the next question to be decided is that of the amount to apply per acre. This depends upon the climate, the natural fertility of the soil, and the crop. Where the rainfall is plentiful and well distributed, much larger applications can be used profitably than where the rainfall is light and summer droughts more frequent. As a general rule soils that have been

| Crops | Light colored soils sandy loams and sands | | | silt loams and clays | | | Dark Loams | | | Mucks and peaty sands | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | without manure or legumes | with legumes in rotation | with manure | without manure or legumes | with legumes in rotation | with manure | without manure or legumes | with legumes in rotation | with manure | Acid | non-acid |
| Corn, oats and barley..... | 2-12-4 | 0-12-4 | 0-16-0 | 2-12-4 | 0-12-4 | 0-16-0 | 0-12-4 | 0-12-4 | 0-16-0 | 0-10-6 | 0-6-10 or potash alone |
| Wheat and rye..... | 4-10-4 or 3-10-4 | 2-12-4 | 2-12-2 | 4-10-2 or 3-10-2 | 2-12-2 | 2-12-0 | 2-12-4 | 2-12-2 or 0-16-0 | 2-12-0 or 0-16-0 | | |
| Alfalfa soy beans and cowpeas.. | 0-10-6 | 0-12-4 | 0-12-2 or 0-16-0 | 0-12-4 | 0-12-4 | 0-12-2 or 0-16-0 | 0-12-4 | 0-12-4 | 0-12-2 or 0-16-0 | 0-10-6 | 0-6-10 |
| Potatoes, Tomatoes, Tobacco, etc..... | 4-10-6 | 2-10-6 | 0-12-4 | 4-10-4 | 2-12-4 or 0-12-4 | 0-16-0 | 2-12-4 | 0-12-4 | 0-16-0 | 0-10-6 | 0-6-10 |

1. In studying this table, it should be remembered that the recommendations are for average Indiana conditions. As regards the use of legumes and manures, statistics show that on the average a legume is grown only once in eleven years and the amount of manure used is only about one ton per acre per year.

2. Where manure is applied directly to wheat or where a considerable amount has been applied to an immediately preceding corn crop and clover is grown in the rotation, acid phosphate or bone meal is all that will be required. On the other hand, where no manure is applied to wheat and where the total amount used elsewhere in the rotation is small, it will usually pay to use a 2-12-2 or 2-12-4 instead of 2-12-0.

3. The potash in tobacco and potato fertilizer should be derived from sulphate of potash.

4. Depending on whether manure is applied to this or some other crop in the rotation.

farmed for many years respond more profitably to heavy applications of fertilizer than newer soils, although, of course, there are many exceptions to this rule. The crop itself is perhaps the biggest factor to be considered in deciding on the right amount of fertilizer to apply. Intensive crops, that is, those having a high acre value, such as tomatoes, onions, potatoes, cabbage, etc., will nearly always pay a good profit on heavier applications than could be made to corn and small grains. For the latter, the best amount will probably be somewhere between 200 pounds and 400 pounds per acre, while for the intensive crops the range will more than likely be from 500 to 1,000 pounds per acre. * * *"

**Lime for Acid Soils.** Lime is a most helpful material for the correction of soil acidity, providing the land is properly underdrained. A failure in getting a good stand of clover is either due to lack of proper drainage or to the fact that the soil is too acid. The appearance of red sorrel in the field is a sure indication of acid in the soil. A very simple test will prove whether or not your soil is acid. Pick up a handful of moist soil, open it up and insert a piece of litmus paper (can be purchased at any drug store), press the soil together again and after fifteen or twenty minutes open it up and remove the litmus paper. If the paper has turned pink or has pinkish spots the soil is acid.

Prof. A. T. Wiancko, of the Department of Soils and Crops, Purdue University Experimental Station, in a bulletin on lime for acid soils, says in part:

"Much of the soil of Indiana is more or less acid or 'sour' and in need of liming before other efforts at soil improvement can give the best results. If the soil is acid neither manures for fertilizers, good cultivation, drainage, nor any other helpful treatment can give the best results. Clover and other legumes, which are among the most potent factors in building up soil fertility, cannot develop properly in acid soils, and when this condition is bad they will refuse to grow at all. The most favorable bacterial and bio-chemical activities in the soil, which make plant food available, are hindered and may be completely stopped by acidity.

"Every soil that is not behaving properly should be tested for acidity, and if found to be acid, some form of lime, preferably ground limestone, should be applied. If not acid, some other condition is wrong. It may need draining, it may be lacking in organic matter and in poor physical condition, or it may be lacking in one or more plant food elements.

"It is not possible to make any definite statement as to the kinds of soil that are in need of liming. Both sour and sweet soils may be found in the same neighborhood or in the same soil type. Many

soils were originally sweet but through years of cropping and through the leaching of lime compounds out of them have become acid; others have been kept in good condition, while some were sour to begin with and never have produced good crops.

"During the last four years over 3,000 soil samples from all over the state have been tested for acidity in the laboratory of the Soils and Crop department of the Experiment Station. Eighty per cent of these samples were more or less acid, and the indications are that every county in the State contains thousands of acres of land that would show excellent results from liming.

**Lime Not A Fertilizer** "It has been pointed out that acid soils must be limed before other treatments can give the best results, but it should be remembered that lime is not a fertilizer.

Effect of Ground Limestone on Acid Soil. This land was acid and would not produce clover. The strip on the right was limed and has a perfect stand of clover. The strip on the left was not limed and has no clover.

It contains neither nitrogen, phosphoric acid nor potash, and cannot take the place of either of these indispensable plant foods.

"The principal reason for liming the soil is to neutralize soil acidity and improve the conditions for the growth of legumes. Legumes can then be used to supply the needed nitrogen, which they can get from the air, but the phosphoric acid and potash must all come from the soil, and if the supplies in the soil are deficient they must be replenished by the use of manures or fertilizers.

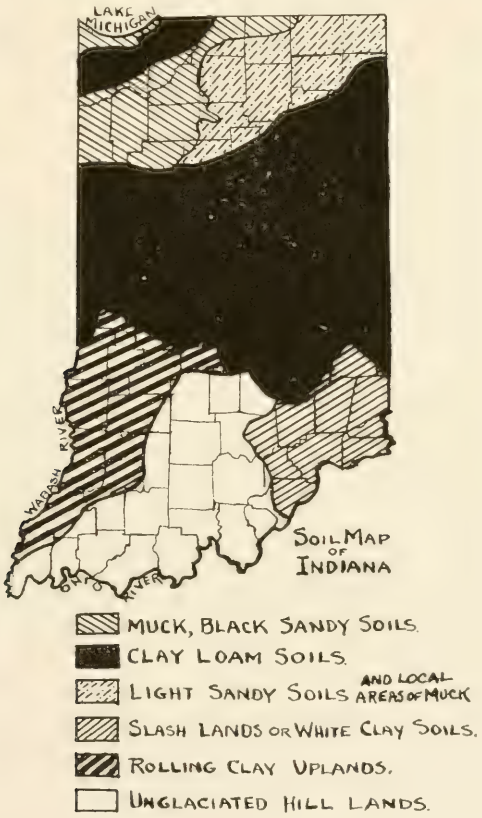
"After the land has been limed and put into condition to re-

spond to other good treatment, the nitrogen and organic matter supplies can be taken care of by returning the manure made from the crops fed, and the crop residues that are not fed or used for bedding and making liberal use of legumes in the crop rotation. On most Indiana soils the phosphorus supply is already too low, so that as much of this element as is removed from the land in crops should be returned in manures and fertilizers. In the case of potash, most of our soils contain abundance for all crop needs, but often it does not become available fast enough. If, however, a good physical condition is maintained and a good system of crop rotation is practiced and the soil is kept supplied with lime and plenty of decomposable organic matter there will be little need for purchasing potash on ordinary soils in cases where the crops are fed and the manure returned to the land. The muck soils, however, are very deficient in potash and the needs of crops must be supplied from outside sources. The peaty sands and the lighter sandy soils also need potash fertilizers to maintain profitable crop yields regardless of liming."

**Soils of Indiana.** The soil map on the opposite page shows in a rough way the various soil groups found in Indiana. The soils are clay loam, reddish brown, yellow, whitish and grey clay, muck, silt, black sandy, gravelly and light sandy with local areas of muck. There are various combinations of these but there is a general run of certain types of soils in the belts as outlined in the map. Different soils need different treatment, some are acid and need lime and phosphate, some require more fertilizer than others, some are high in organic matter while others are low in same, some are acid and low in organic matter, others are acid and high in organic matter, others are only slightly acid and low or high in organic matter, as the case may be. Some need all the available materials in varying proportions, others need only the application of one or two. About one-third the soils of the State are acid but 90 per cent of all of our soils need acid phosphate. Large areas are in need of potash and nitrogen as well. Only about 8 per cent of the crop acreage is growing clover, an insignificant percentage in consideration of the amount of land that should be growing clover and other legume crops to give nitrogen, open up the soil and give it air space that will assist the tile in their good work.

**Clay Loam Soils.** The greatest proportion of clay loam soils in Indiana are located in the central and northern parts. Not all of the soils in the area indicated are clay loam soils for there are other types of soil found in the lake region of Northern Indiana and also along streams such as sandy soils and local areas of muck, but the large majority of soils covering nearly half of Indiana are

clay loam soils. These were very fertile in their virgin state, but many have been cropped so long without correct rotataion that they are not yielding the grain they would be capable of if proper application of correct farm practice were made. The prairie soils found in the west central counties are usually abundantly supplied with nitrogen and organic matter although many of the soils are in need of phosphate. The other portion of the clay loam belt was in the




past generally heavily timbered and this type is usually low in nitrogen and organic matter and acid in varying degree, hence requiring both lime and phosphate. The growing of legume crops in crop rotation with wheat and corn would be beneficial. The application of two tons of ground limestone or its equivalent is considered by Prof. Christie to be sufficient to correct the acidity of acid clay loam soils which contain enough aluminum compounds to require lime and

phosphate to render harmless the poisonous nature of these compounds.

In speaking of the remedy to be applied to the large acreage of clay loam soils which are acid and low in organic matter, Prof. Christie states:

"This soil needs, first of all, at least two tons per acre of ground limestone which may be applied at any convenient time during the rotation and it can be applied either before or after breaking the land. But liming is only one step in the improvement of these soils. Plant food and organic matter must also be added. Manure gives excellent results but crops must be grown and fed before manure can be grown and fed before manure can be produced. Moreover, unless concentrated feeds are purchased in considerable amounts, manure can not add plant food. By using lime, available phosphorous and potash on corn and complete fertilizers on wheat the yields will be brought up to a profitable level in the shortest possible time and good crops of clover can be grown. Bigger crops mean more organic matter either as manure or crop residues, such as straw or cornstalks, and more plant food and lime where needed mean bigger crops. Scores of farm demonstrations conducted by county agents during the last few years have shown the great value of this plan of soil improvement."

**Unglaciated Hill Lands.** A triangular area embracing the counties of Monroe, Brown, Lawrence, Crawford, Martin, Orange, Perry, Harrison, Spencer, Warwick, DuBois, Washington and portions of Pike, Gibson, Vanderburg, Jackson and Clark, is known as the Unglaciated Hill Lands of Indiana. As the name implies the soils found there were not affected by any glacial action in prehistoric days and remain about the same as they were in the olden days, being residual soils affected only by the elements, wind and water. The soils are not altogether alike in this section although most of them are of a reddish brown color. Some are brown or yellowish brown, others yellow and still others grey. Some of the soil is quite like the yellow clay soils of the rolling clay uplands adjoining this section on the west and the whitish yellow clay soils of the slash land belt on the east. Most of these Southern Indiana soils are silt loam. They are acid in varying degree, the subsoil being more acid than the surface soils as a general rule and needs drainage first then the application of lime and phosphate.

Experiments by the Purdue University Experimental Station on their plot near Bedford, Lawrence County, prove that these soils require liberal applications of lime, acid phosphate and manures. Prof. Christie advocates four tons of ground limestone, 300 pounds of 16 per cent acid phosphate and six tons of manure to the acre. Experiments showed that the untreated soil is very unproductive,

that the application of manure was very valuable, but without the use of lime and acid phosphates crops cannot be grown to produce the manure needed.

**The Slash Lands.** That section of the State covering the southern eastern corner of the State, extending through Franklin, Dearborn, Ohio and Switzerland Counties to the Ohio River and west into and covering all of Jefferson, Jennings and Scott, the southern portion of Decatur, eastern part of Jackson and upper eastern Clark County, is known as the slash lands, consisting principally of silt and white clay. This is sometimes called white clay land and also crawfish land. The soil in the section is the most uniform in the State and has been farmed longer than any other section of Indiana. On undrained soils the chimneys of the crawfish are much in evidence, standing six to eight inches high.

This is a soil decidedly in need of drainage, lime, fertilizer and manure. In its original state, it is almost valueless, especially that portion extending through Franklin, Ripley and Dearborn Counties, the oak timber formerly found there was the real incentive for the locating of settlements there in the early days. With the depletion of the timber, farming was very unsatisfactory until correct farm practices were instituted. The experimental plots located at Scottsburg, Scott County, North Vernon, Jennings County, and New Point in Decatur County, showed that the undrained land would not grow satisfactory crops and without lime it was too acid to grow clover. The land thoroughly tile underdrained and given four tons of ground limestone, 200 pounds of acid phosphate and six tons of manure to the acre, produced the best results with great increase in crop yields. These experiments also proved acid phosphates to be far superior to rock phosphates. One experimental field showed a gain of 24 bushels of corn and 416 pounds of clover hay per acre for drained land in comparison with undrained land proving that drainage is the first and all important step. Crop rotation including clover and use of lime and fertilizer are essential.

**The Rolling Clay Uplands.** The rolling clay uplands extending along the Wabash River and embracing the Counties of Vigo, Clay, Sullivan, Knox and the greater part of Gibson, Posey, Pike, Daviess, Greene and Owens, consist of yellow or greyish clay with the exception of the river or creek bottom lands where foreign soils have been brought down from the clay loam region. The rolling clay uplands are acid and require not only drainage and lime but also phosphate and nitrogen since they are deficient in both phosphorous and nitrogen.

The results of experiments on the Purdue field at Worthington, Greene County, where the soil is grey silt loam and similar to rolling

upland of several counties, farmed for many years decidedly "run down," subsoil more acid than surface soil but not nearly as sour as the "slashland" or "hog prairie" of Northwestern Indiana, showed that where no treatment was given, corn yielded 32.7 bushels, wheat 9.7 and clover hay 2,398 pounds per acre, but with addition of six tons of manure increase was worth $26.93 with crops at present prices. The increase from lime and manure was $30.80 each rotation, but where acid phosphate was used on corn crop in addition to lime and manure, the yields were further increased by $15.67. Potash used in addition to lime, manure and acid phosphate also showed gain. The proper treatment for this type of soil seems to be tile underdrainage then two tons ground limestone, six tons of manure and 200 pounds of acid phosphate on each corn crop, and 200 pounds of 0-8-4 fertilizer on each crop of wheat.

**Muck and Sandy Soils** In the valley of the Kankakee River, extending through Newton, Jasper, Pulaski, Stark, St. Joseph and Elkhart Counties, also touching portions of Lake, Porter, LaPorte and White Counties, as well as the shore line of Lake Michigan, there are numbers of soils differing greatly in make-up, more so than in any other belt in the State with sand, muck, gravel and clay intermingling in varying proportions. These soils are peculiar to themselves and we find where formerly the mosquito, the frog and fowls of the swamp lands thrived and cat-tails and wild growths were the chief plant life, since the area has been drained many rich farm lands have been built up, growing a great variety of products. There are onion fields growing 700 bushels to the acre, peppermint and spearmint fields with valuable yields, farms devoted almost entirely to the raising of sunflowers or truck farms, in fact intensive farming has been going on there for many years past. Onions, peppermint, potataoes and truck and vegetable crops are grown on the muck land, alfalfa, cowpeas, rye and cucumbers are raised successfully on the lighter soils while corn and small grains thrive on the lands containing proportions of clay. Experiments by the Purdue Experimental Station showed that potash fertilizers were very necessary for these soils often doubling and trebling the yields of corn, potatoes and onions. Available phosphate also added to the value of the crops. Only a few patches of muck land are acid so that as a general rule the use of lime on muck soils is not necessary but the black sandy soils found on parts of LaPorte and Porter Counties also spots in Starke, Pulaski, Jasper, Lake and St. Joseph, known as "hog prairie" soil, are very acid and lacking in lime and phosphates.

Experiments at Wanatah, Laporte County, on corn, oats and wheat showed that corn on untreated lands made from 1 to 18 bushels but the addition of four tons of limestone and 400 pounds of 2-10-8 fertilizer per acre the yield went as high as 59 bushels per acre. A

forty-acre field of same soil gave a yield of 70.7 bushels per acre in 1911 three years after lime and fertilizer had been applied. J. A. Warren near Kouts, Laporte, County, raised 127 bushels of corn per acre in 1920. There are yellow sandy soils, sandy soils with some organic matter and other soils with proportion of gravel, found in this belt. Complete fertilizer containing a large amount of potash is very beneficial to these soils as well as frequent application of lime and the growing of legume crops.

The Purdue University Agricultural Experiment Station through its excellent corps of experts, its experimental plots and the county agents is doing a splendid work in the study and the dissemination of knowledge regarding the needs of our soils. If your soil is not producing bumper crops better see the county agent or send a sample of your soil to Purdue with the request for information regarding the exact requirements of your soil. Follow the suggestions given and you will profit greatly thereby and it will help in the advancement of our agriculture.

## TILE UNDERDRAINAGE

**The Real Basis of Improved Farming Conditions Resulting in Amassed Wealth of the Large Majority of Our Progressive Farmers Is Underdrainage, It Not Only Protects and Improves Fertility But Gives You a Second Farm Under Your Present Farm You Could Not Otherwise Use.**

Underdrainage is defined as the art of removing from the soil and subsoil any excess water that would likely interfere with its seasonable preparation for sowing or planting farm crops or retard or injure their growth and development. Within the following pages we prove that it is not a new idea but a matter thoroughly practical and necessary in increasing the productivity of the land and that tile underdrainage assures among many the following advantages: Removal of excess water, prevention of loss of soil fertility, and the correct preparation of the soil, making it more productive, drouth resisting, easier to cultivate and permitting of an earlier planting.

Drainage for agricultural purposes antedates Christianity. We have proof of this in the writing of Columella, an agricultural writer, who lived in the reign of Augustus and Tiberius.

**A Little of Its History**

We also find reference to underdrainage in Cato, Varro and Virgil proving conclusively that drain tile were used in those olden days in farm drainage. The ancient Romans used clay pipes as conduits for water, evidence of this and also the fact that the people in lower Austria, Saxony and other countries used a similar system of conduits by clay pipes can be found in some of the cultivated fields today. So we may safely say that clay pipes of tile were used in drainage work even before Christ. They were presumably the invention of the Romans.

Another statement that will perhaps interest the farmers of today, touching on the value of clay tile in drainage work is found in an article written in 1880 by G. Harnow, a Member of the Agricultural Society of France at that time. (This is published on the opposite page.)

## DURABILITY OF TILE IN DRAINAGE WORK.

"Within the town of Maubeuge, France, in my own neighborhood, was a convent of monks. * * * The convent did not escape the republic of 1793, and the aspect and inmates have changed, but its wide and splendid garden was respected. Was it on account of its reputation? It was well known that, from immemorial time, it was renowned for its fertility, the beauty and earliness of its fruit and the friability of the soil.

"The estate was sold, and last year the premises underwent repairs; the prolific garden was turned into pleasure ground; park with fountains; driving causeways; artificial elevations of ground, and so forth. This overturning disclosed the secret of its marvelous reputation: Two complete and regular pipe drains extended throughout the whole garden at the depth of four feet. One of the drains had all its pipes radiating to a sinking well situated in a central position; the other was made of pipes all parallel, ending at a collecting pipe which discharged into a cellar. The owner had the kindness to give me two pipes as specimens of curiosity. They are about ten inches long and four inches in diameter; one end expands into a funnel-shape, the other tapers into a core; they are made of an argilo-silicious composition like most of our earthenware, which is very hard and becomes very much glazed in burning, thereby becoming unalterable. All were found well preserved; they were evidently made by hand and lathe. No particular data is given as to when the drain was constructed. MSS. left by the monks might solve the question; at any rate, some tombs placed over the drain in 1620 show it to be anterior. Here, then, is ancient drainage, made with master hands, '260 years ago,' which in its dimensions, system and material, is much like those of the present day."

In the excavations made today of the ancient buried cities, clay tile are found in a perfect state of preservation. This proves conclusively that the ancients knew what they were doing in preparing their drainage systems. The ancient may have thought the world was flat, but he was progressive so far as drainage was concerned. Clay drain tile are being used in England today, taken from fields where they were laid as far back as 1810.

So we see that there is ample evidence that tile underdrainage is not a new idea, that different ancient peoples believed in it and left for the future generations the impressive examples of the benefits of using common sense reasoning in draining their land.

We do not have to delve into ancient history, however, to prove the value of tile underdrainage, for there is evidence close at hand for every farmer in the State of Indiana.

During the past seven years we have been making an investigation of the conditions in the Hoosier State, visited the farms in various counties, and we have found that the successful farmers were those who had tile drained their farms, while the most failures were due to lack of proper drainage. Let us cite a few cases where the farmers are meeting with success and reaping big profits from their crops. We visited a number of farms in Fayette and Franklin Counties and interviewed the farmers, finding them, for the most part, enthusiastic advocates of tile underdrainage, for reasons set forth below.

**What Tile Underdrainage Did for Dan Broaddus**

One of the first farms we visited was that of Mr. Dan Broaddus, who owns a 120-acre tract of land four miles north of Connersville. He was just completing a splendid brick residence on his farm that would have done proud to any large city. This residence was made possible by the big profits made during recent years on his farm. It was not a paying farm a few years ago, for the cold clay soil made a poor farm land. There was an excess of water, the soil was too compact, and it didn't have the life and accessibility for air conducive to good plant growth. In endeavoring to improve the land, he experimented in various ways with the manures and commercial fertilizers, but the ground was so dense that the rainfall washed the fertilizers into the gullies, so that the subsoil was little benefited. The ground was plowed and harrowed, but the excessive water was still there, and the winter freezings kept the soil in the same old condition. Finally, a small section of land was tiled, a great deal of the excess water was thereby removed, the soil was thus made more porous, permitting the air to get down to the roots of the plants and give them the air fertility they needed. The fertilizers remained in the soil, adding greatly to the productivity of same. The first planting showed a wonderful improvement, and each succeeding year brought

a larger crop. Every year he put in more tile, until his whole farm was tile-drained. This farm is producing over thirty bushels of wheat to the acre. When we were there, we walked through wheat fields over four feet high, and the heads were well formed.

**More Than Trebled His Yield First Year Tile Were Laid**

Charles Thomas, who owns a farm a short distance from that of Mr. Broaddus, proved the value of underdrainage. His land was by no means swampy, for it consisted of high, rolling ground,hardly enough level land on it to gather water. The soil was light grey in color, the subsoil a hard, dense formation. The water penetrating the soil was halted when coming in contact with the subsoil, causing this land to become foul and sour. For several years he attempted to make his land more productive with the aid of commercial fertilizer and lime, but his efforts were not rewarded with any increased production. He simply needed to ventilate his subsoil, a condition which exists on thousands of farms in Indiana today. As a last resort, he tried tile underdrainage, which absolutely solved the problem and turned a poor farm into splendid paying investment. Where forty bushels of corn to the acre was a good yield, he is now producing nearly seventy bushels. The year before the land was drained he produced seven bushels of wheat, and that was a representative yield in that county on undrained farms. He took each field as it came in rotation for corn and laid in a good system of tile drainage, and then followed with wheat and clover. He put in 5,500 feet of clay tile each year, until the entire farm was underdrained. The entire lines were sixty to eighty feet apart and thirty to thirty-six inches deep. The tile were mostly four-inch tile, but a quantity of five and six-inch tile were used. The first year after the tile were put in, the yield of wheat leaped from seven bushels to twenty-five bushels to the acre, and each succeeding planting of wheat brought a larger yield. He is growing alfalfa where it was impossible before, for the subsoil became more open and thawed earlier and prevented the freezing out of the crop.

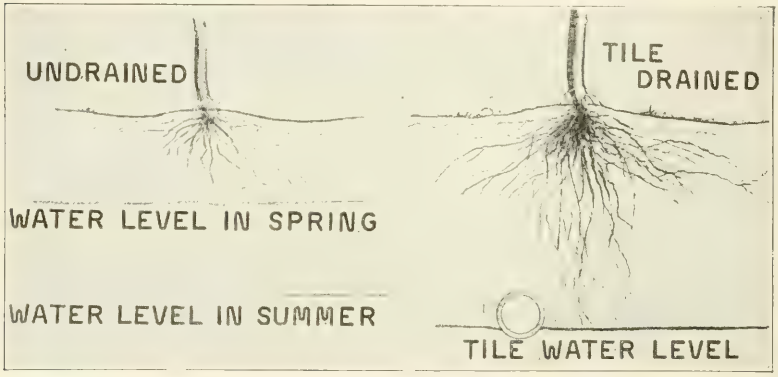
We asked Mr. Thomas what he thought of tile drainage. He stated that he owed everything to it; that it was an absolute necessity, and he wouldn't be without it for any consideration. "Why," he said, "there is seemingly no end to the benefits of tile drainage. Before, plowing was difficult, for the ground was so dense; now, it is surprisingly easy and allows me to do the plowing much earlier; therefore, I can plant much sooner and harvest early without fear of delay until the fall frosts. While the ground was cold and close-grained before, it is porous now, and I get a better effect from the fertilizer. Before, I could dig a hole most any place and find water in the clay within eighteen inches of the surface. The farmers around Harrisburg

thought I was crazy, to tile my farm; they laughed at me and joked about my ditching the hillside, saying it was a foolish idea to drain where there were no swamps; but they are all tiling their farms now, since they learned what tiling was doing for me. Tile drainage is the only thing."

He showed us a field of rye that was standing over five feet high, a beautiful sight waving in the bright, hot sunshine.

Mr. W. E. Higham, who had plowed this farm years before, when a boy, stated that formerly the ground, when plowed, seemed to have a hard board floor underneath, and that they never had a good crop until Mr. Thomas tiled it.

This farm consisted of ninety-eight acres; every part of it was




Which corn root can do the best job of producing corn?

On the undrained side the roots had to spread out close to the surface in the early part of the season because the soil below was full of water. Later, when the land below dried out, it was so hard the roots couldn't go down into it; anyway, they were already established in the top soil. When hot, dry days come, that shallow-rooted plant will suffer and burn and yield no crop.

Tile drainage is one of the best ways to stop soil washing or soil erosion. When the water runs away through tile drains, it doesn't make gullies in the surface.

Courtesy The International Harvester Co.

clean and orderly; the barnyards were free of rubbish and the usual scattered machines and odds and ends; everything had its place, and a spirit of real pride pervaded the entire premises.

**An Occular Demonstration of the Value of Tile Underdrainage**

We came to a field of clover, in which we walked kneedeep, as one of the illustrations shows. This was on tile-drained land. Directly across the road was another field of clover, with numerous bare spots, the plants scanty and scarcely reaching the shoe-tops. This was the same kind of land as the other, but not tile-drained, giving us a very good object lesson in the effects of same. The owner is thoroughly convinced of the need of drainage now, and is going to tile his farm.

The Heavy Crop of Clover Raised on a Tile Drained Farm.

Scanty Growth of Clover in Field Across the Road Not Tile Drained.

There are other numerous large crop-yielding farms in Franklin county. We stopped at one of them. This one happened to be owned by the late John Hoffman, three miles north of Brookville. He was getting from sixty to seventy-five bushels of corn to the acre, where formerly twenty-five bushels was all that could be expected. The same development was shown in regards to the other crops. He was harvesting thirty-six bushels of wheat to the acre, while previous to tiling he got only eight to ten bushels. Two acres of oats now bring 142 bushels; before, it was only one-third of that amount. Mr. Hoffman had no end of good to say about land drainage.

We stopped along the road to Brookville and called a farmer from his plow. It was Mr. John Rohmer, who owns a large farm, and delights to work in the field, although getting on in years. Asking for a statement relative to the benefits of tile drainage, he waved his hand and shouted: "Go ahead and say anything. You can't say too much in favor of clay tile and tile drainage; it pays big and is the only thing to do. Why, look at the big crops I am getting, and just think, I can plow so much earlier and easier." His production is three to four times larger than before he thoroughly tile-drained his farm, and increases each year. Mr. Rohmer had the same condition to overcome as did Mr. Thomas.

We met farmer after farmer, and it was the same thing over again. They had had ocular demonstrations, had tiled their farms and were reaping the big harvest and enjoying the happy, prosperous life they deserved for their enterprise.

**Effective Work Of Geo. Schebler**

There is a wide strip of land extending through Franklin and Ripley Counties and down into Dearborn County, covering almost 400 miles, a part of the section of the state known as the Slash Lands. The soil found there is entirely different from the soils found in other sections of Indiana. From the beginning these lands were sour and contained very little fertility. The only timber that would grow on this land was white oak, and so low was the fertility that the oak grew very slowly, hence making a fine, tough grain. The decayed trees and leaves did not add much to the fertility of the soil, as in the case of timber on the other types of soil, for the white oak contained tannic acid in a proportion that prevented the soil from becoming rich in fertility. After the land was cleared of its timber the people turned to farming, but with continued failure, for the land could not produce more than 8 bushels of wheat to the acre or 15 bushels of corn. For years farmers endeavored to enrich the soil with manure and commercial fertilizers, but in vain, for the water could not carry the fertilizing elements into the subsoil; the surface soil was too dense.

It was in this section of the state, in the midst of the Slash Land, that Mr. George Schebler, inventor of the Schebler Carburetor, when

he retired from the automobile business, not craving a life of leisure and loving the outdoors life, looked around for a location where study and planning would be neecssary in farm work. He did not buy land rich in fertility. He preferred to take the seemingly worthless, worn-out land and do his part in making it into something worth while.

He became interested with his brother John in a farm one-half mile west of Hamburg, between Hamburg and Clarksburg, in Franklin County, which for fourteen years was yielding only 10 to 12 bushels of wheat, sometimes 5 or 7 bushels. Fifteen bushels of corn was the average. This was decidedly unprofitable, but was all the land would produce under the conditions.

Some farmers in that part thought that it could not be made productive, that it would be a waste of money to try to improve it. Mr. Schebler made a careful study of tile underdrainage, realized it had worked wonders in other soils, and became convinced that it could make this poor land pay and pay big.

He tiled fifty-four acres thoroughly, using four and five-inch tile, thirty to forty feet apart and thirty to thirty-two inches deep. After he had put in the system the yield jumped from ten or twelve bushels to eighteen bushels, and every succeeding yield was greater until in 1917 the yield was thirty bushels an acre. On one part of his farm the yield was thirty-three and three-fifths bushels an acre.

I received the following letter from Mr. Schebler, which is self-explanatory:

Batesville, Ind., Dec. 6, 1921.

Mr. J. E. Randall:

Dear Friend—In reply to your letter asking about tile underdrainage and the benefits holding out—in other words, the increased benefits from year to year—wish to say that tile underdrainage in soil like on my farm surely has great lasting benefits. It has sweetened the soil, made it porous, and enabled the air and water to carry into the soil the fertilizing elements. With lime and underdrainage we got rid of the acid condition and now our crops are surprisingly good. We had a thirty-acre field of clover last year that could hardly be improved upon. We got three tons to the acre, where before we could scarcely get a stand. We fed this to the cattle, and what we couldn't return to the land in manure we turned under. This enriches the soil and prepares it for the next crop. This field of clover was a fine demonstration in favor of underdrainage and also liming.

The field of wheat you saw yielded 33 bushels to the acre. Remember, we only got about 12 bushels to the acre before the tile were put in. You can say for me that there are so many benefits after you get this land tiled that they are too numerous to mention. Tile underdrainage is the fundamental principle.

Yours truly, GEORGE SCHEBLER.

So well satisfied was Mr. Schebler with the results obtained on this seemingly worthless soil that he bought up other farm lands in that part and began to put in tile underdrainage systems on a large scale. He bought a ditching machine, operated it himself and ditched thousands of rods. He is a godsend to that part of the state, and through his efforts that part he is developing will blossom forth as one of the best producing centers of Franklin County.

I was pleased to spend a day with him on his farm between Oldenburg and Batesville, where he tiled ninety acres in 1917, and even more than that in each succeeding year.

He knows he will get good yields, now that the land is tiled, and has prepared for same. He has built a large, fine barn, 84x42 feet, sixteen feet under the eave trough, with self-supporting roof and sixteen-

A Splendid Crop of Wheat Grown in the Slash Land.

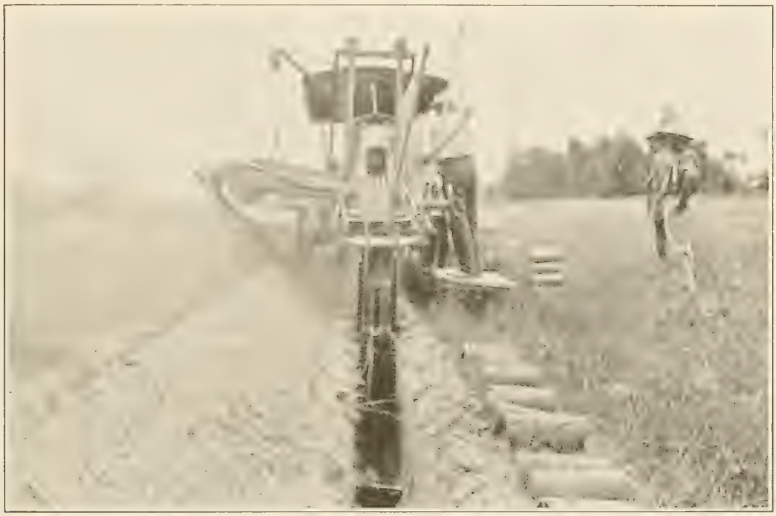
foot rafters. It is a splendid, modern type structure and will suit the purposes admirably.

There are a number of farmers who have had the same experience and have converted their slash lands into profitable farms.

The slash lands of Indiana remained in their poor state for years because the farmers were not progressive and knew little or nothing about the requirements for good plant growth. Finally one real up-to-date farmer changed the whole aspect. He used common sense, tiled his farm and began to reap big harvests. His farm improved each year and still has not reached its highest point of efficiency. He lives in a brick house, has large barns and fine stock, owns an auto and has money in the bank, because his tile are working for him. The slash lands of Indiana have hardly been scratched yet, but the farmers

are learning the value of tile underdrainage, so that ultimately the entire section will be converted into profitable farm land.

**The Clay Loam Soils** We visited Marion County and saw the splendid results farmers were getting on tile-drained land and the poor crops they were experiencing on the undrained land. This section is in the clay loam belt of Central Indiana. We spent considerable time on Mr. Sterling R. Holt's farm, which is located on the Rockville and High School Roads, extending one mile from the Rockville Road south along the High School Road. There are 160 acres; 76 acres on the northern end was formerly known as



Ditching Machine at Work on Schebler Farm. Mr. Schebler Operating Machine.

the old Stout Farm. Mr. Holt has changed this from an unprofitable farm to a money-producing investment, for while in the years past, before it was underdrained and proper treatment given, it would yield less than 25 bushels of corn to the acre at best, today the average is better than 70 bushels of corn to the acre. The land now is producing heavy crops of alfalfa where before it would not grow at all, because water drowned it out and in its place weeds grew in abundance. After this land was tiled and a liberal application of lime-rock was made, farming here proved a pleasure for many reasons. The other portion of the farm was formerly the Charlie Hanch Farm, which had been rented for fifteen years and no care taken at all by the succeeding tenants. Mr. Holt purchased the land recently and is thoroughly un-

derdraining it. Since it is the same type of soil and in the same condition as he found the old Stout farm, by like treatment he will have all 160 acres producing equally splendid crops in a very short time.

While walking over the farm with Mr. Holt I asked him what influence drainage had on alfalfa, and the following was his reply:

"Well, sir, answering that question, I'd say you cannot separate the two, for tile underdrainage is the chief essential in good alfalfa growth. You see those fields of alfalfa over there? I've grown nothing but alfalfa on them for the past sixteen years, and I get around five tons to the acre annually. I can just sit here and let it grow; it does not need the care other crops do. Year after year I cut those

This View and Picture on Opposite Page Are Scenes on the Adjoining Farms Referred to. This Field Produces Three Good Crops of Alfalfa Each Year, Due to the Underdrainage and Proper Treatment.

fields three times a season and never reseed. I just run over the ground both ways with spring-toothed alfalfa harrow after each cutting. This throws out the weeds and grass.

"Of course, it wasn't that way in the beginning. That land was cold clay land and too wet for any kind of crop.

"The only thing for me to do if I were going to make my land worth anything at all was to change that condition, for the previous owners went broke trying to grow crops there without changing the soil much. Oh, they plowed it and put manure on it, but that didn't do any good, for the land was dense and wet. The crops were bound to be drowned out. The soil had to be made porous and the excess water removed. Drainage was the only sensible thing to do.

"I studied the subject carefully, knew I had to tile drain that land and determined that tile should be put in systematically or not at all. When I tiled I hired an expert and had the systems laid according to the requirements. My tile are 30 inches deep and all the lines 60 feet apart. Do you know, I was surprised myself at the wonderful change the tile made in that land the first year. Every bit of the expense, and more, was made back right off the jump, for I raised double the crop I had before, and the beauty of the whole thing is it seems to get better every year. I've made up my mind that I can't tile too much, for it opens up the soil, removes that excess water and allows the air to circulate down deep.

"It was like trying to plow over a board floor before, that ground was so hard and dense, and there wasn't much life in the soil either

This Field with Same Type of Soil, but Wet, Due to Fact it is Not Underdrained Grows Scarcely Anything but Weeds. Drain Tile Would Change This Soil From Unprofitable to Profitable Farm Land.

because the ingredients needed in the land from the rains and manure had been washed away into the gullies by the surface washings simply because the ground was too dense. The rains and melted snows could not percolate very far.

"It was a hard job to get scarcely any kind of a crop before I tile drained. But when I had those tile working for me there certainly was a surprising change. The ground was easy to plow, the soil was rid of its dampness and close structure and there wasn't the surface washing. The water would not stand in that ground after a rain, for the tile carried it off, but the fertilizing elements needed in the soil were retained and not washed into the gullies.

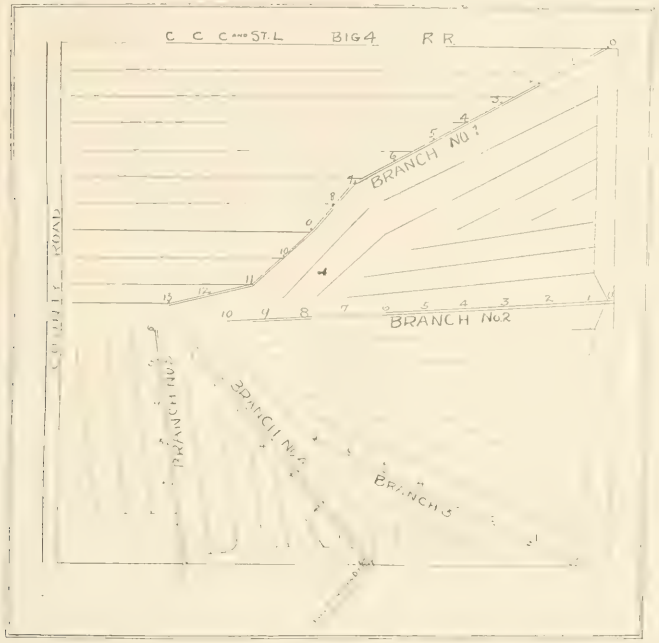
**Lime Sweetens Soil** "Of course, I put on a liberal quantity of ground limestone to sweet the soil before I did any planting, and then I went to it. That alfalfa grew wonderfully and has never given me one bit of trouble since. I attribute my success in growing alfalfa to the fact that I have a well tiled farm and sweet soil. So when you ask me what I think of the influence of tile underdrainage on good alfalfa growth, I simply have to admit that I can't separate the two, for I don't believe you can grow good alfalfa on any but tiled ground.

"Tile underdrainage is essential in the growing of any crop if you want to make big profits, but it is more essential in growing alfalfa or the other deep-rooted plants than in growing any other kind of crop. For corn you need a deep clay loam, while for wheat a lighter soil will do; rye you can grow in most any place, but tile underdrainage will give your land a big advantage over your neighbor's if his is not tile drained."

He turned suddenly in his walk over his alfalfa field and pointed to a field of an adjoining farm covered with weeds.

**Weeds or Alfalfa** "Do you see that mass of weeds over there across the road? Well, that belongs to a neighbor friend of mine who is going to tile in the spring. His soil is exactly as mine was once, but he hasn't been able to grow alfalfa because the ground is too wet. He has tried it for years now and has finally made up his mind to follow my example. All the lime and manure in the world wouldn't make that land good for alfalfa without a drainage system. Doesn't that field of weeds and the knowledge that he has tried it time and again prove it? Of course it does. I am going to plant twenty acres more in alfalfa this year. I'll break ground in the spring and cultivate it until the last of July, running an alfalfa harrow over it about every ten days. Then I'll sow it with a drill, using about eighteen pounds of seed to the acre. Another good way to start growing alfalfa is to sow in oats or barley and then your alfalfa. Last year I put in a new field, sowed alfalfa and barley April 1st, and in June got 32 bushels of barley; on September 1st cut over a ton of alfalfa to the acre off same piece of ground. I could have made another good cutting, but I preferred to let it stand to take care of the new alfalfa during the winter. Next year this field will give me splendid crops of alfalfa.

"I like to use plenty of lime and phosphate. They do the soil a lot of good. I'll use four to six tons of ground lime rock this year, applying it with a lime spreader. I think 200 pounds of 16 per cent. acid phosphate to the acre is about right. It gives good roots. The best time to put in the phosphate is just after the cutting, when you're running over the ground with a fine-toothed alfalfa harrow.




DESCRIPTION OF BRANCHES AND LATERALS.

Branch No. 1 consists of 10-inch tile from Point 7 to Point 0, and 8-inch tile from Point 13 to Point 7, there being 42½ and 36 rods, respectively. Branches Nos. 2, 3, 4 and 5 are all of 8-inch tile, there being 60½, 42½ 46 and 36 rods, respectively. All the laterals were laid with 5-inch tile, 1,421 rods in all. There are 221 rods of 8-inch tile and 42½ rods of 10-inch tile. In Branch No. 1 there is a rise of 90-100 foot a hundred to Point 7; 1 6-10 feet to Point 8; 90-100 foot a hundred to Point 11 and a rise of 1½ feet a hundred to Point 13. There are 618 rods of laterals emptying into Branch No. 1. Branch No. 2 has a rise of 95-100 a hundred to Point 3; 75-100 a hundred to Point 8, and 1 28-100 feet a hundred to Point 10. Three hundred and ten rods of 5-inch tile drain into this branch. Branch No. 3 has a rise of 95-100 foot a hundred to Point No. 4, 2½ feet a hundred to Point 6 and one foot to Point 7. One hundred and ninety-six rods of 5-inch tile drain into this branch. Branch No. 4 has a rise of three feet a hundred to Point 4 and 1½ feet a hundred to the end of the branch. There are seventy-one rods of five-inch tile draining into this branch. Branch No. 5 has a rise of two feet per hundred to Point 3 and 1½ feet a hundred to Point 6. There are 148 rods of 5-inch tile draining into this branch.

The ditches for the tile were made by a ditching machine. All the tiling was laid thirty-six inches deep. There are open ditches at the end of each outlet.

"I cut my alfalfa three times a year, the first about June 1st, the second about the middle of July and the last in September. Alfalfa brings a good price. It makes the finest feed possible; we keep our horses fat through the winter with no other feed. We don't have to feed them any grain at all."

**Alfalfa Roots in Tile** I asked him if he had ever heard of the alfalfa roots entering the tile and being bad in that particular, and he replied that it was not reasonable to think that alfalfa could give any trouble in that respect. "Why, the alfalfa roots are fine and are near the surface except for the one main root, which, of course, sometimes penetrates to a depth of fifteen feet. These main roots do not interfere with your drains because they would not go through, but would go around or probably miss the tile entirely. Alfalfa, you know, can't stand much water. Even if the alfalfa roots did get into the tile they would rot off in no time, so that it wouldn't affect your drains any. Why, I've grown alfalfa for over twenty years and have never had one single bit of trouble with my drains.

"There are but few sections of land in the State that cannot grow alfalfa with the proper preparation of the soil. Probably every farmer in the State really desires to grow alfalfa, but many are under the impression that their land is not suited for raising it. If he will only try out a part of his farm, put in a good system of tile underdrainage, make the soil sweet and make a good seed bed, and thus prepare his soil before planting, he will prove to his own satisfaction that great opportunity he has neglected. Remember this: Alfalfa needs a dry subsoil, and the tile underdrainage makes this possible. On most land the tile should be put in every sixty feet, and a liberal application of good lime rock made. This will make a good stand of alfalfa.

"The influence of tile underdrainage on good alfalfa growth can not be expressed by words. It is the profits in dollars and cents that speak unmistakably of its great value and importance.

**Value of Hairy Vetch** "Another thing that does our land a lot of good is hairy vetch. We put in about forty pounds of seed of hairy vetch to the acre every August. It grows up in the fall, giving a lot of fine pasturing, covers the ground in the winter, and then in the spring it grows along the ground until it is five feet long, covering the ground all over. It is fifteen to eighteen inches long the middle of May, and can be pastured or turned under. This plant gathers a great amount of nitrogen, a needed element for plant growth. The roots of the plant become white with its abundance of nitrogen, there are great knots of it, or rather nodules, as they are called. This plant also helps to loosen up the soil. This is a help, but tile drainage is the only way in which you can make a farm pay in the manner it should."

**Relation of Underdrainage to Soil Conditions**

A very interesting example of what tile underdrainage will do for soils lacking in fertility is that of a field now growing excellent crops of alfalfa near Sweetzer, Ind. Four feet of the surface soil was removed for use in the manufacture of tile and the soil at that depth was naturally without an appreciable amount of fertility. The land was thoroughly underdrained with four-inch tile thirty inches deep and the following year planted in corn with the resulting yield of 76 bushels to the acre; the following year alfalfa was sown and three heavy cuttings were secured. The picture shows the field as it appeared the latter part of September. Another remarkable thing about this soil is the fact that the surrounding undrained land is not

Tiled Land Which Produced Excellent Alfalfa, Formerly Low in Fertility.

as fertile now as the soil found four feet below and underdrained. This proves that underdraining pays and that in land where roots can not go down to a sufficient depth they do not reach a wide enough area of plant food storage.

**What Underdrainage Did For the Brewer Farm**

The writer had the pleasure on one of the hottest days in July of visiting the excellent farm of Edgar D. Brewster in Johnson county, Indiana. While old Sol was playing havoc with thermometers and humans in general, the temperature reading around the century mark, the interest the farm afforded made the writer forget about

the heat and he was glad to take pictures from the metal roofs of the sheds or while standing on top of one of the numerous high fence posts. It was indeed a most interesting and fascinating farm, due to the splendid yields, the variety in the crops, the methods of farming, the feeding and the care of the cattle.

The farm consists of 117 acres of well-drained land. That year seven and one-half acres were in alfalfa, the yield being six tons to the acre on the average. Eleven acres in oats brought 30 bushels to the acre, the same amount of land sown in barley brought the same production. Four acres planted in kaffir corn brought the enor-

Mr. Brewer in Field of Corn That Yielded Nearly 90 Bu. Per Acre.

mous yield of twelve tons to the acre. Twenty-two acres were in red clover and gave a good, clean crop. Forty acres were planted in corn, which produced about ninety bushels to the acre. The writer was informed as to the above facts later and was not surprised in the least, for when he was there in July he witnessed fields of corn that looked like young forests, walked through alfalfa fields over knee deep, and was amazed at the thick, tall growth of the kaffir corn.

Everything about the farm spoke in no uncertain language of progress and prosperity. The entire farm was well fenced and clean

in every particular. The driveways, watering places and exercise yards were neat and healthful in appearance and the cattle, horses and hogs were fat and of fine quality. Everything in the sheds and the barns was in place, and there was a delightful absence of old, discarded equipment and rubbish heaps. I took particular note of the hollow tile feed storage house, which seemed to me the ideal place for storing oats, rye and the small grain. Another interesting feature to me was the grove of catalpa trees which covered several acres, affording a much-needed shade for the live stock on those hot days. The hog pens underneath the corn bins also did not escape my attention. The

The Alfalfa Field Ten Days After the Second Cutting.

statement, made above in regard to that year's yield, would sound good to the average farmer. Mr. Brewer is well satisfied with the production of his farm, but he says it is going to yield even more to the acre next year, because he has his drainage system working for him, making his land richer and better and the manures and limestone used are having a splendid effect.

This farm was somewhat different in looks, yield and everything else, way back in the 80's when Mr. Brewer's father was working it. The times were different then, the country round about was wilder and there was very little known about the real benefits of tile underdrainage and the best methods of installation. In those days the elder Brewer used tile, and they did good work, too, but they were small tile (2 and 3-inch) and couldn't begin to relieve the ground of its wetness. The land in this section of the country is what is termed beech land, a cold clay, close grained soil very difficult to get water

through. Where the best corn is raised on this farm today, wild geese and ducks floated around upon the water of a now-vanished pond content with the wildness of the spot and the protection afforded by the underbrush in the days of forty years ago.

Before the 80's the farm was tiled in a small way in the beginning, and additional drains were placed as time and money would permit. It was in the 80's that the larger tiles were first put in and results were so gratifying that every year more extensive work in drainage was done until the farm was thoroughly tiled. It is needless to say that the thickets soon disappeared and the pond was a thing of the past. While a lot of the small three-inch tile remain in the ground and are still in working order and in perfect condition after forty

**A Bumper Crop of Wheat on a Well-Drained Farm.**

years of use, these lines will later be replaced with larger tile, located at a greater depth, even to four and five feet.

In an interview with Mr. Brewer he said in part—"Farming to me is a real pleasure, there is no drudgery to it to me now since the land is in such excellent producing condition. I wouldn't do without my tile system for any consideration for that you know is the real backbone of my farm. This land was formerly so dense and close grained that you could scarcely get any appreciable crop off of it. The plants were choked and they didn't have a healthful place to live in. We couldn't open the ground up much with plowing and, of course, as long as the soil was dense and cold the fertilizers had no effect. Every

rain washed the manure and fertilizing elements into the gullies, and the plants had to live in the excess water which stood in numerous places on the land. The only solution to this kind of condition is tile under-drainage. My father saw that in the early days and he did the best he could with the conditions of that time. He did the pioneer work of cleaning the land and getting a drainage system started. My work has been to enlarge upon his work and to take advantage of modern methods and equipment. I put 4 to 8 inch tile in every few rods until I had the entire 117 acres drained and then began to put in more tile between lines.

"It is a great mistake for farmers not to tile; it is the best place they can bury their money, for it is always a safe investment and will increase the earning power of the land as the years pass by. If you

A Poor Stand of Corn on Wet Ground—Drainage Would Pay.

tile in this latitude you are always sure of your crop for it is safe from drought or a wet season. You don't need anything but natural manure, barnyard manure and clover for inoculation and a little lime rock to sweeten the soil.

"While ditching, I sometimes run onto a line of two-inch tile my father put in before the 80's and do you know they are still carrying water. These old tile are only 16 inches below ground. Of course, my drains go from 30 inches to 4 feet. My main lines are 4 feet deep. I wouldn't put any line in less than 30 inches deep. Nearly all my tile is put in now three spades deep (a 16-inch spade being used). I believe in careful attention to the rotation of crops and like to plant corn, barley, oats and clover. I don't raise any wheat for my farm is purely a stock and feed farm. That, I consider the best way to farm, for the

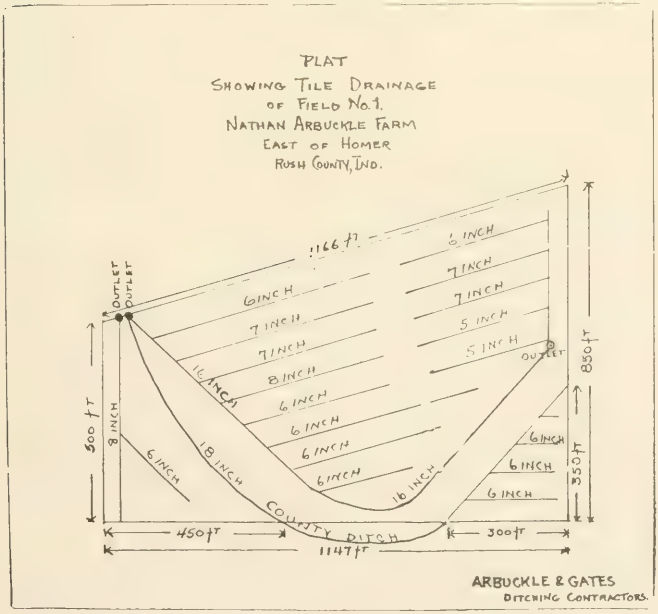
grain and fodder you grow will fatten your stock and then you can put it back into the ground again in the manure. After the corn I have rye in the fall and pasture the hogs then plow it under in the spring."

**Got Rid of a Bad Overflow** We paid Mr. J. W. Arbuckle a visit recently down in Rush county, Indiana, where he was ditching a corner of his father's farm. The ditched portion consisted of 17 acres of sugar-tree land that had been an eyesore on the farm due to the fact that every spring this land was the catch basin of the overflow from many of the surrounding fields and was left in a condition of little value for farming. Tile underdrainage was the only remedy for such a condition, and now that it is thoroughly tiled, splendid crops will take the place of the meager yields and rank weeds formerly grown there. An illustration of this underdrainage system is shown herewith. Five, six, seven and eight-inch tile were used for laterals, feeding into a sixteen-inch main and also an eighteen-inch county ditch. The large sizes of tile in main drains were required because of the unusual amount of overflow experienced here. Ordinarily an eight-inch outlet would be sufficient for handling the water from the land.

Mr. Arbuckle ditched 520 rods on this farm, finishing the work in five days. A small Buckeye ditcher was employed. He operates a larger ditcher for work requiring greater than ten-inch tile. Work by the big machine is based on 5 cents per inch per depth of trench.

**In Shelby County** Near Flat Rock, in fact right across the road from the entrance to the park of the Flat Rock Cave, eight miles south of Shelbyville, Shelby County, is located the farm of Elmer Toner. Mr. Toner purchased this farm in March, 1921, and has nearly completed the work of thoroughly underdraining the 153 acres it embraces. He formerly lived on the farm which had been thoroughly tiled by his grandfather in Hendricks Township, Shelby County, and sold the farm only because of the unusual high price offered for it. After a two years' vacation he decided to take up farming again and purchased the present farm, which had been tiled to some extent ten years ago and had given a 50 per cent. increase in yield. The undrained soil had grown 35 bushels of corn to the acre, but after being tiled raised 70 bushels. This would seem satisfactory to the average farmer, but Mr. Toner's previous experience had taught him that he could hardly over-tile his land. He decided that the system was not thorough enough, and while this was level land of the sugar-tree yellow clay soil, he set to work, carefully surveyed the farm and installed an elaborate system and when they cut into the old lines these were repaired and allowed to function in addition to the new system.

This Machine Averages Better Than 150 Rods Per Day.




Drainage System on Arbuckle Farm.

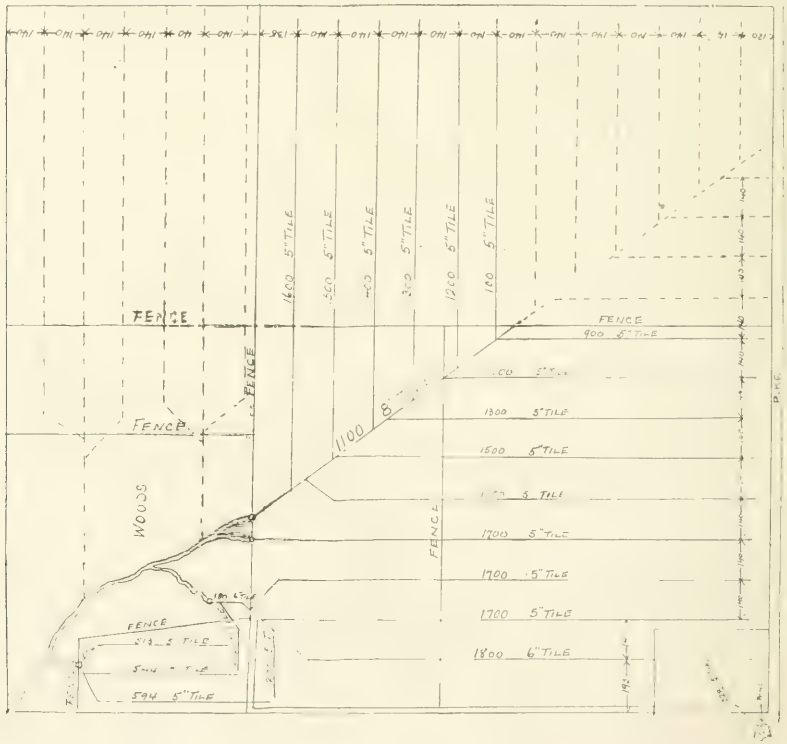
As the accompanying sketch shows, the lines were 140 feet apart, extending over the entire 153 acres. The average depth is 44 inches and the size of tile ranges from 8 to 5-inch. The main lines are 8 and 6-inch tile, while the laterals are 5-inch; about 25,000 feet of tile had been laid up to October. Mr. Toner states that he is contemplating putting in lines between the new ones, making the distance 70 feet apart. The tile are not being put in because the land is swampy or wet, for land has no free water. The drainage system is installed to let nature do its real work of getting the fertilizing elements into the soil air.

The following letter received from Mr. Toner shows his views on tile underdrainage.

"Flat Rock, Ind., R. No. 3, November 16, 1921.

"Mr. James E. Randall, Indianapolis, Ind.:

"Dear Sir—Pursuant to your request, I am sending under separate cover a chart of the tile drains employed on my farm. The dotted lines represent drains to be put in after harvest of next year. All the



other drains are in excepting five acres south of the woods, on which they are now working. There were a number of drains already on the farm in good condition. They were repaired, when cut through, and will do as much as before. It seems extravagant, but it is not so. The farm will pay the bill with interest in increased earnings. My faith in drainage is founded on practical experience, results gleaned from the research of soil experts. It is my belief that this branch of soil improvement is first of all in importance in the betterment of soil conditions and soil production. Productiveness is determined by the capacity of soil to hold moisture and the completeness with which the roots of plants can utilize it, along with the soluble salts which it contains. Water in soil is harmful when it excludes the air, thus suffocating and poisoning the roots of plants and living organisms. It is helpful when it surrounds the soil grains as a thin film, permitting the air to circulate and supply oxygen and ventilation to the plant roots and to soil bacteria. The chief benefit of farm drainage seems to be to areate the soil, to increase, by carrying off the stagnant water, the pore space, and thus permit the free air to penetrate and occupy. Professor King, an authority on soil physics, says, 'that when water drains away from soil or is carried upward and out by capillarity or root action, it acts by suction to draw into the soil a volume of air equal to that of the water which flows out.'

"Drainage lowers the ground water so that roots are able to penetrate to a greater depth, feeding on the plant food found there, decaying in their turn and leaving passageways opened up for yet more air and oxygen to enter.

"A well-drained soil is warmer and earlier than one which is wet because of the influence of the evaporation of moisture on soil temperature, and the chief reason why an undrained clay soil is colder than one well drained is because of the cold generated by the process of evaporation. Sandy soils are warmer than clay for the reason that sand has a smaller capacity for water and they drain naturally.

"The pleasure of working a well-drained soil is worth much. Tile drains put soil in a mechanical, a physical, condition which conduces materially to ease and comfort of operation.

"Hoping that this is something like what you wanted, I am

"Yours very truly,
(Signed) "ELMER TONER."

**The Marsh Lands of Indiana**

If there are any people on the face of the globe that are enthusiastic supporters of tile underdrainage it is the people in Marshall County, Indiana. All the successful farms in that part of the country are tiled, even the farms with high sandy soil.

"Seven hundred bushels of onions to the acre—that's what tile

underdrainage did for us here where three years ago we were wading through the marshes in boots hunting pheasants." This was one of the expressions used by the superintendent of the N. W. Erickson farm, Polk Township, Marshall County, Indiana, made during our conversation while walking over his onion fields.

This farm is located four and one-half miles southeast of Walkerton, on the old Laporte road, an old Indian trail known as the old yellow river road. It is only one of many farms built up out of the marshes and is not the exception, many of the other farms in that region being larger producers. It is the onion district of the Hoosier State, millions of bushels are produced annually from the land reclaimed from those old swamps and marshes.

Three years ago you could not get a team out without bog shoes, it was considered "mighty poor farm land" and a decidedly unhealthy place in which to live. Not so today.

The knowledge of a few simple facts and the nerve backing up conviction made this great change possible. Much credit is due those men who have turned these marsh lands into a rich farm section. It took real nerve and it required great perseverance to grub this section, clear it of its useless brush and undergrowth and to prepare the way for drainage. Once the tiles were laid, the foundation for great returns was secured.

The tile did the work, the excess water was removed and the rich soil buried or hidden away for ages stretched out in the sun where it could take on a new life. With the removal of the water the unhealthy condition disappeared and this formerly mosquito-breeding section became a delightful place to live in.

**The Erickson Farm** Let us visit the N. W. Erickson farm and listen to the story of its superintendent. "You say you want to know what tile underdrainage did for the marsh lands of Indiana? Well, I can't say too much in praise of tile. It has given us everything in this section. It has given us healthier conditions, it has lifted up our lands so to speak, has given us something to grow crops on and after the giving has made that soil open and porous and has made possible our use of its rich fertility, enriching the soil in its work."

Six years ago Mr. Erickson cleared a section of the land here and raised onions in a small way. Of course, as soon as he had grubbed it he put in a system of tile underdrainage to remove the excess water, that was absolutely necessary. The first year's crop of onions was so satisfactory that he enlarged his farm and more thoroughly tiled his land. Each succeeding year more land was cleared, open ditches and tile drains were put in so that today this farm consists of eighty acres of as rich soil as one can find in any part of Indiana.

As we walked over the field of both set and seed onions he pointed

out the outlets and the territory of the main drains. Fourteen, twelve and ten-inch clay tile are used for the main drains, while five-inch tile are the smallest sizes used in the laterals. He showed me the forty-acre field planted in corn and the four-acre plot of potatoes and then continued his narrative.

"The average yield in onions is 500 bushels. Two years ago we made the record yield of 700 bushels to the acre and got 40 to 70 cents a bushel in the patch. Will do that again. Our past season has been a little off.

"The business has grown so large that we have had to hire at times nine men to help us out. We plant as early in the spring as possible, just as soon as the frost is out of the ground. There are nine

An Onion Field on the Erickson Farm, Which Produced 700 Bushels to the Acre. Tile Underdrained.

acres in sets and twenty-one acres in seeds. The seed onions are put in after the sets. We find along about the 10th to 17th of April is the best time to plant. The set onions are harvested about the middle of July, while the seed onions the last of August. We grow the yellow and red globe varieties. The first year we crated and marketed in Walkerton, but the business grew so large we had to store them, hence the building of that large barn over there and the store house adjoining it.

**Handling the Crop**

"The onions are taken from the field and dropped into bins from which they are taken and crated as soon as convenient. The crated onions are stored away

in a storage holding 13,000 crates. Just before the heaviest selling time for us the storage is entirely filled.

"When you consider the fact that we receive from 40 to 70 cents a bushel in the patch and raise over 500 bushels to the acre each season you can figure how profitable onion growing is in this section. Remember this is in a place that for hundreds of years was considered an eyesore, a health destroyer, a swampy marsh, good for hunting only, a place where mosquitoes thrived and the muskrat lived in peace and satisfaction. The underdrainage did all this, and I can not say too much for it. It removed the excess water from the soil and made the land tillable. It opened up the soil and allowed the air to circulate and the nitrogen, that much-needed element, to work down to the plant roots. Of course, this land was rich in fertility from the decayed vegetation of centuries; it did not need tile drainage for that in particular, but it did absolutely need it to make the fertility useful. The tile makes the soil warmer and permits us to plant earlier because the frost goes out quicker than in land not tile drained. We have plenty of water yet in this section, but in case there is a drouth tile will make our land drouth resisting simply because it only takes off the surplus water and retains the water needed which passes back to the surface by capillary action.

**Benefits of Drainage**

"There was never anything manufactured of more benefit to the onion growers of this section than tile. We couldn't use the modern conveniences here today if it were not for tile underdrainage, for without it we would be living in the marshes with the tormenting insects, the fever germs, the croaking frogs and the song of the red-winged blackbird."

Tile underdrainage has indeed worked wonders in that section. But it is not there only that the drainage has a great value. It is profitable to put in drainage systems in high land as well as in the low wet land. No matter whether the soil is dry or wet,, tile underdrainage has its function. The dry land may be too compact so that the fertilizing elements are washed away into the gullies with the passing rains. Tile underdrainage opens up the soil and allows the elements needed to percolate down deep to the plant roots and retains the water required by the plant.

**In the Rolling Clay Uplands**

Down in the southwestern portion of Indiana the soils are yellow or greyish with the exception of the river bottom or creek bottom lands, where foreign soils have been carried and deposited there from the clay loam region to the north. This land is greatly in need of drainage and the application of lime phosphate and nitrogen.

The use of good farm practices in Sullivan County has produced record crops. The C. L. Davis farm west of Sullivan—good black

soil and thoroughly underdrained in 1916—has produced 100 bushels of corn to the acre. On the Frank Mason farm, south of Sullivan, high creek bottom land tiled in 1912, better than 100 bushels of corn to the acre have been produced, while previous to tiling the crops were always uncertain. John McNab, south of Merom, has a tiled farm that is also in the 100-bushel class.

J. T. Akin owns a farm near Carlisle that has been tiled for nearly

Bumper Crop of Corn, Sullivan County, On Drained Land.

twenty-five years. It produces around 40 bushels of wheat to the acre, while the Pogue farm near Fairbanks has yielded as high as 41 bushels of wheat. Willis Drake, south of Fairbanks, averages around 38 bushels of wheat, and Charles Riggs, near Staffordshire, has done better than 44 bushels. Will Riggs has a farm near Fairbanks that is a good object lesson on tile underdrainage. In 1917 on an undrained portion of the farm he raised 21 bushels of wheat to the acre, but on

the tiled portion of his farm the yield was 38 bushels per acre with the same cultivation and seed.

We hear farmers remark that they do not need tile underdrainage, that their land has such a great amount of natural drainage that underdrainage is not needed. This is a great mistake. Remember tile underdrainage is essential in both hilltop or rolling lands and in low lands. Tile underdrainage helps you in time of wetness or drouth, for the simple reason that it removes the surplus water that is a detriment, but retains the water needed for the growing plants and supplies same in time of drought due to the capillary action.

At a drainage convention at Purdue Prof. W. H. Stevenson, one of the leading authorities on underdrainage in Iowa, made the follow-

Poor Stand of Corn, Sullivan County, On Undrained Land.

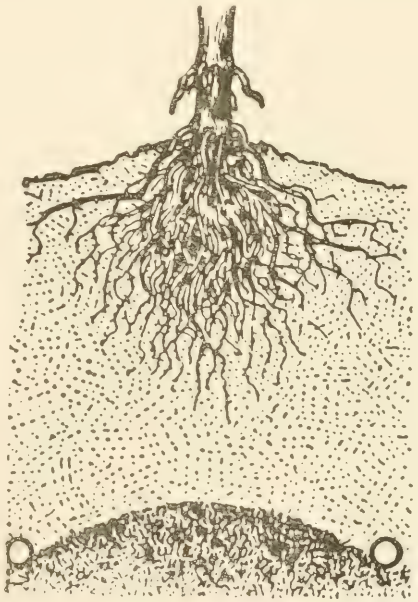
ing reply to a question asked as to whether or not there was any difference experienced in very dry weather through the tile drainage of land:

"Under no conditions does a tile drain remove water from the soil which is or will be needed of value to that soil or the crop that grows on it. That is true because the tile drain takes from the land only surplus water—water which we call surplus because it is not held by the soil particles. The only relation that the surplus water bears to tile land and the crop is a nuisance. No season is so dry that any water that the tile has taken out would have responded beneficially. I know a farmer who had a farm that cost him $1,200. It had two or three ponds and was very wet. He spent $2,000 or $3,000 on

drainage and doubled the income. I know of many farms in our State which are absolutely unproductive, not partially, not spotted with just certain bad places, but absolutely unproductive, because they are too wet. That land may be worth $10 to $20 per acre in that condition. There is almost no reasonable limit to the amount of money a man can spend on that land to get it into shape for cultivation because it will pay him back a hundredfold."

There are a good many farmers who ditch out their black land and let their clay soil go without ditching, not realizing that the clay

Root Development of Corn in Poorly Drained Soil.



In Well Drained Soil Roots Go Deep and Are Not Affected by Drouth.

soils need draining as much as black soils and will produce as equally good crops as black soils when thoroughly drained. Remember that old adage, "Drain well, drain deep, and you'll have corn to sell and keep." It is just as true as this little verse:

"And who have tried it firmly say
That draining land is sure to pay,
And farmers' barns are filled with corn,
While frogs must emigrate or mourn."

There isn't any question as to the benefits of tile underdrainage.

The writer is convinced that nearly every reader fully appreciates what tile underdrainage will do for his land. However, there are thousands of farmers in this country who have not thoroughly drained their land, the reason for such neglect perhaps being due to a question of finance or a lack of knowing how. We point out the ways and means in the following pages.

**How to Install Underdrainage Systems**

First, have a general plan. It is work that can be done a little at a time if desired, but a plan embracing all that will need to be done to complete the entire drainage of the farm should be determined upon. Map out the system for every acre of your farm and then tile the low places first, working back to the higher ones. Always begin at the outlet and progress with the work as conditions will allow until the undertaking is well done. Many have followed this plan until they completed the work without any extraordinary expenditure of money at any time, depending largely upon the profits accruing from the work already done. First one field is tile drained and put to profitable crop production then another field is treated in like manner, and so on until all the fields are tile drained, but of course in accordance with the general plan mapped out at the beginning.

After deciding to tile your farm, make a careful study of the land and be sure you are correct in your theories before proceeding. Proper knowledge of tile underdrainage and how to do it is, of course, absolutely essential in putting in the correct system for your farm. It is the particular points in installing drain tile systems that we care to discuss in this part.

Since your tile underdrainage is to be a permanent system, it is all important that you have no weak point in same, as for instance, the lack of an open free outlet for the water or a failure to maintain a regular incline of the tile allowing depressions in the drain lines where the silt may deposit and lessen the capacity of the tile drain, either of which may render ineffectual and useless an otherwise well-executed system of drainage costing money and labor.

**The Outlets**

First of all if tile underdrainage is to pay, all the surplus water is to be taken care of, therefore our first attention should be directed to the outlets. We should have a fair idea of the amount of water there is to be drained off and our main drains should be sufficiently large to take care of more than this amount of surplus water. We, of course, must take into consideration the general surface configuration of the entire farm and surrounding watershed and by taking levels and carefully studying same we can determine how many outlets to have and just where to locate same. An engineering level can be secured at a slight cost and used successfully by the novice if the farmer can not secure the services of a com-

petent drainage engineer or surveyor. Of course, the safest plan and the most inexpensive plan in the end is to have a man of drainage knowledge to outline your work.

It is, of course, all important to know just where the outlets should be located for the free flow of the water and the main and sub-main drains must be accurately placed to secure the best results. The lateral drains are easily installed after the main and sub-main drains are once located. We must know what fall can be had in the different drains (including all), for the size of the tile to be used depends upon the fall and the amount of water to be taken care of. Larger sized tile are needed for drains having less fall, the length of the system, of course, governing this. The greater the fall the more rapidly will the water pass through the tile and a great amount of water can be taken care of. It is necessary also to know the character of the soil and subsoil, the water passing through some soils much more rapidly than others. Beginning with the outlet, it should be located at the point which will give the greatest fall and direct outflow of water to drain the area mapped out for that system, and should be placed as deep as the conditions make it feasible. Generally this does not exceed at the most 4 or 5 feet. This, however, should not be a fixed depth. The tile for the main drain should be sufficiently large to carry all the water that will run onto or fall on the area to be drained by the outlet.

**Size of the Tile** In regard to the size of tile, the writer is pleased to include in this article the facts stated by his grandfather, J. J. W. Billingsley, who for many years before his death was the editor of the old Drainage Journal and did extensive lecturing before the farmers of the Central States on underdrainage and farm problems.

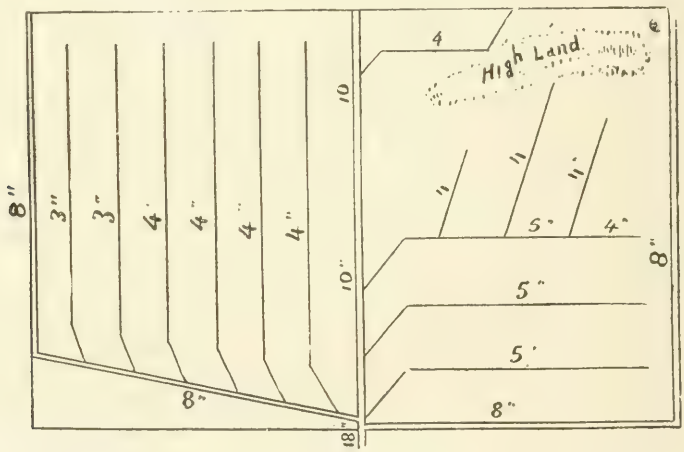
"The size of the tile to be used depends first upon the extent of the area to be drained; second, upon the inclination or fall, and third, upon the depth of the drains and the character of the soil and subsoil."

First, as to the area to be drained. To illustrate more fully: A proposes to drain twenty acres of land through one outlet, and wishes to determine the size of tile for the main drain. He finds that there is an area of as much as twenty acres of land adjoining that sheds its surface water from rainfalls and water percolating through the soil upon and into the land of the twenty acres which he wishes to drain. The natural outlet is over or through A's twenty acres under consideration. Therefore, the tile for the main drain and sub-drains should be large enough to receive and carry the watershed onto the land.

For a simple rule for those who wish to construct drains through the low places of the farm, a practical drainage contractor gives the following as the result of his experience: "On an average the fall

usually secured is about 6 inches in 100 feet. With ordinary accurate work in securing a regular fall, a 3-inch tile drain will carry the water of six acres; a 4-inch tile will drain eight acres; a 6-inch tile twenty acres, and an 8-inch tile eighty acres." The above rule is for casual, not thorough, drainage.

Second, the inclination or fall is an important factor in determining the size of tile to be used. The greater the fall the greater will be the rapidity of the water flow, increasing correspondingly the amount of water discharged through the drain. A 4-inch drain may have fall enough to carry as much water as would flow through a 5-inch drain laid with much less fall. A main drain may be laid at almost a level grade and do good work, but the size of the tile should be larger in




First Have a General Plan of System to Be Installed.

proportion to the less fall for the reason that the water will flow less rapidly than would the water in a drain with much more fall.

Third, the depth of the drain is also a factor in determining the size of the tile needed to secure the most efficient drainage. The greater depth requiring a less size, when the fall is the same as that of a drain laid at a less depth, other conditions being equal.

The increased depth gives an increased water pressure in the soil, which increases the water flow in the drain. Another reason why the size of the tile may be less in deep drainage is that the greater the depth of the drained soil and subsoil, the more water there will be required to bring the deeper subsoil to the point of saturation, when the water will fall away and enter the drain. A soil drained to the depth

of 4 feet would receive and hold the water of a heavy rainfall almost to the point of saturation before the water would pass into the drain. The deeper drainage will aid in conserving needed moisture for the growing crops.

Drainage in England is usually at a depth of from 4 to 5 feet. In their retentive clay soils the drains are laid from 20 to 30 feet apart, the tile used are small, 1½-inch and 2-inch being in common use for the latter drains; with almost perfect construction their drains do good work. But in the experience of some of our most extensive

Get Your Tile Early and Place Where Drains Are to Go.

land drainers in this country a 4-inch tile is as small as they will use for the side drains to carry off the water of heavy rainfalls, besides it is claimed that by using larger tile a better aeration of the soil is secured.

Another factor in determining the size of tile to use is the method of constructing the drain, the regularity of the fall, the directness of the flow of water in the drain and the laying of the tile.

A drain may be dug and leveled correctly, but the laying of the tile may be so imperfect as to greatly diminish the working capacity of the drain. By placing the tile in the drain unevenly jointed, or shouldered, more or less, the water in flowing through the drain strikes against the shoulders and deflects across the current, hindering

the flow, reducing the capacity of the drain at every uneven joint.

We advise against the use of 3-inch tile in almost every case because we feel it is poor policy to put in small tile where a larger one would sometimes do 50 per cent. better work. It does not cost any more to lay a 4-inch tile than it does to lay a 3-inch.

**The Depth of the Drains** The depth of the drains of course depends on the nature of the soil and levels of the outlets. If it is impossible to get the outlets down to four or five feet below the general level, shallow draining is, of course, the only way out, but that is better than no drainage at all. In speaking of deep or shallow drainage, it is generally conceded that a depth of four feet or more is deep drainage, three feet medium drainage and 2 to 2½ feet shallow drainage. Deep drainage relieves the soil and subsoil of surplus water to a greater width and makes the fertility available for plant growth to a greater depth and needed moisture and affords a greater range of root growth, so necessary to the growth of plants. The deeper the drain the deeper your food bed. Three to four and a half feet depth is advisable when feasible, but the average depth generally used is around 36 inches.

**Distance Apart** The character of the soil and subsoil and the fall and inclination should of course govern the distance between the lateral drains. Two rods apart is as close as is thought necessary in the most retentive soils, the depth being 3 feet. When the soil is more open, 3 or even 4 rods distance apart will prove satisfactory, providing the drains are 3 or more feet deep. In some very open soils with the drains placed at a depth of 3½ to 4 feet, the laterals may be laid at 80 to 100 feet apart. If put in at this distance under the conditions mentioned the soil will be drained and aerated sufficiently. These drains should join the main or sub-main drains at acute angles to prevent the water from the laterals from interfering with the current in the lower drain. With the current flowing as nearly as possible in the same direction with that of the drain into which it empties naturally the drainage water is taken off faster.

**Putting in the Ditches** Of great importance is the digging of the ditches. It must be done carefully. Hand digging takes time and labor and is really more expensive and not as successful as machine digging. We advise the use of the ditching machine and it is not a difficult matter to secure the services of a competent ditcher, who will not only dig the ditches, but will help you make your plan and do all the work necessary. We will speak of ditching by machine a little later.

If you dig your own ditches be sure to have the sides slope to the bottom of the ditch, the bottom being just large enough for the tile

to fit. In leveling the bottom of the ditch use a small scoop the size of the tile. Remember that you must have a general fall in your line. You can readily see if this is so by the flow of the water from head to mouth of ditch.

**Laying the Tile** When you begin laying the tile, start at the lower end of the ditch, join the first tile to the main or sub-main drain by chiseling a hole into main line to suit hole in lateral tile and cut the latter to fit snugly up against the other. If possible get fitting to suit your case; this, however, is most times difficult, for the majority of tile manufacturers do not make them. In making the union be sure to cover the cracks with pieces of broken tile. Fit the second tile closely to the first, etc., seeing that your tile are straight

Covering Tile With Straw Before Filling in is a Good Practice.

so as to have a perfect alignment and regular fall. Do not leave space between the tile, thinking this is necessary to allow the water to get in. You can't place them too tight. If the water is flowing in the ditch, do not let it wash any loose dirt into the tile, cover the end of the tile with a small board while getting the next tile. Cover the tile at the ends of the lateral and main drains with gravel or broken tile, for otherwise soil or mud may wash in and clog up the system. It is good practice to install in the mouth of the outlets iron traps, which can be purchased for a small amount. These cover the mouth and have a swinging gate which allows the water to flow out, but prevents any ground hog or rabbit getting into the tile during a dry season,

which will result most times in the animal getting caught, thus clogging up the system. After the tile are laid throw in a little dirt from the top of the bank, being sure not to dislodge the tile. It is good practice to cover the joints with sod or weeds or even paper to prevent the dirt from entering before you have the tile well covered. After the tile are covered the ditch may be filled in any way convenient. Many farmers plow the soil in on either side.

**Ditching by Machine** The most economical and satisfactory way to ditch your land is by means of the ditching machine. It will make a straight ditch, give a more accurate fall and accomplish the work with a saving in time and labor. The ditch does not need to be as wide with the machine as when dug by hand.

The illustrations shown are from pictures taken on the farm of

Fig. 1—Digging Trench for Excavating Portion of Machine.

Elmer Hutchinson, located near Arlington, Ind. We spent a very pleasant day there and were interested in the work done by the ditching machine of Frank Meltzer, a farmer who became a ditching contractor through his thorough belief in tile underdrainage and a desire to ditch his own farm with his own machine. He is being kept pretty busy in his county these days filling ditching contracts. We do not believe we could show the advantage of using the ditching machine over hand digging in any better way than by describing what we saw on the Hutchinson farm that day.

They were putting in the laterals eighty feet apart, joining a main drain which had been completed the day preceding. The main drain emptied into an open ditch skirting one side of the farm. Fortunately this open ditch was low enough to allow them an outlet nearly

nine feet below the general level of the farm. A rather steep fall was secured for 2 rods back of the outlet and then there was a gradual inclination from a 50-inch depth. The main drain was made with 7-inch tile, all laterals are to be 5-inch tile. In starting a ditch (see Figure 1) they dug a trench eleven feet long and the depth of the desired drain at the main drain for the placing of the excavation portion of the ditching machine in the start of its work. When the hole was dug the ditching machine was backed up to and over it and the digging portion lowered into same. (See Figure 2.)

When the machine was located correctly a transit was screwed into a sight rod on the machine (see Figure 3) and the engineer took

**Fig. 2—Lowering Excavating Portion of Ditching Machine into Prepared Trench.**

the site (see Figure 4) on paddle stakes with cross arms which were placed at various points along the line where the ditch was to go. By moving the cross arms up or down as was necessary to get all cross arms on the same level, a definite guide was secured. The transit was then removed and the engineer took his seat on the side of the machine where he could look over sight rod all the while the machine was moving forward along the line digging the ditch. By watching the cross arms sighted over the sight rod the operator could tell when to lower or raise the excavating wheels to any depth or height needed to keep the bottom of the ditch to the slope giving the desired fall. Of course, when the machine would come to a hilly spot

Fig. 3 –Placing Transit onto Sight Rod.

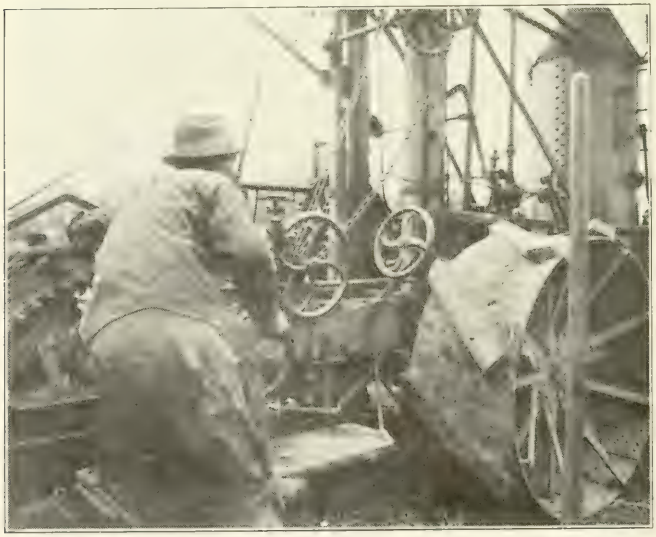


Fig. 4—Engineer Using Transit to Get Proper Location of Cross-Arms on Paddle Stakes Placed at Certain Distance in a Line to End of Field.

the excavating wheels would be lowered and more dirt would be removed and the reverse was true when a low spot was reached.

As the machine made rapid headway along the line a boy was carrying tile and placing them along the top of the ditch while a second was placing them in the ditch. This latter operation was most interesting. (See Figures 5 and 6.) The tile were lowered into the ditch and placed in line close up to the last tile by means of a tile hook. This was a mallet-shaped arrangement made out of an 18-inch long, 3-inch square piece of wood fastened at the middle onto a long pole. Both ends of this mallet had rounded edges so that either end could be poked into the tile laying on the ground and same lifted up and lowered into the ditch, the tile not being touched after it left the

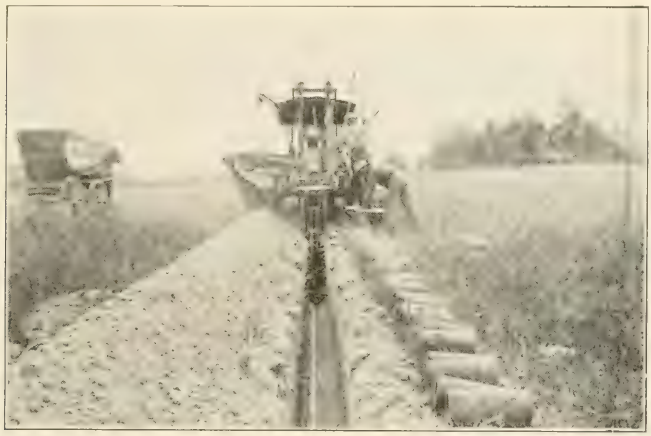


Fig. 5—The Machine in Operation—Note Dirt Is Dropped to Left from Flying Belt.

ground. This work was done rapidly and required no man in the ditch to see that the tile were straight. In fact the ditch made by the ditching machine was not wide enough for a man to get into. Following the man with the tile hook came the ditching contractor with a pair of long props which he placed down in the ditch, one on one side of the end of a tile while the other was on the opposite side of the ditch and on the closest end of the tile adjoining. By a scissors-like movement these two props adjusted the tile so that they were in true alignment. It was a simple though clever "stunt."

The last operation was the hoeing in of the dirt into the ditch. Plowing in is a faster operation. It did not take long for the first lateral to be completed. Of course the machine got quite a little ahead of the tile layer due to the fact that the first tile placed had to

be fitted to the main tile line, the chiseling out of which, the shaping of the lateral tile and placing broken tile around the cracks taking a few minutes.

In an interview with Mr. Meltzer he stated that he could tile 67 rods in 4 hours and 20 minutes with ordinary weather and soil conditions. He said he thought that a 2-inch fall to 200 feet was good on the average farm, but that they were doing much better than that on the Hutchinson farm, getting 18 inches to 3 feet in 200 feet. Five feet is the lowest level to place your drainage system, he declared. When

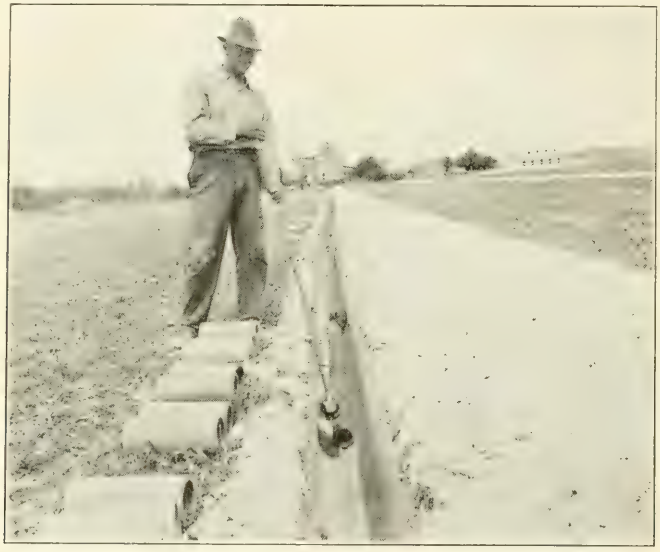
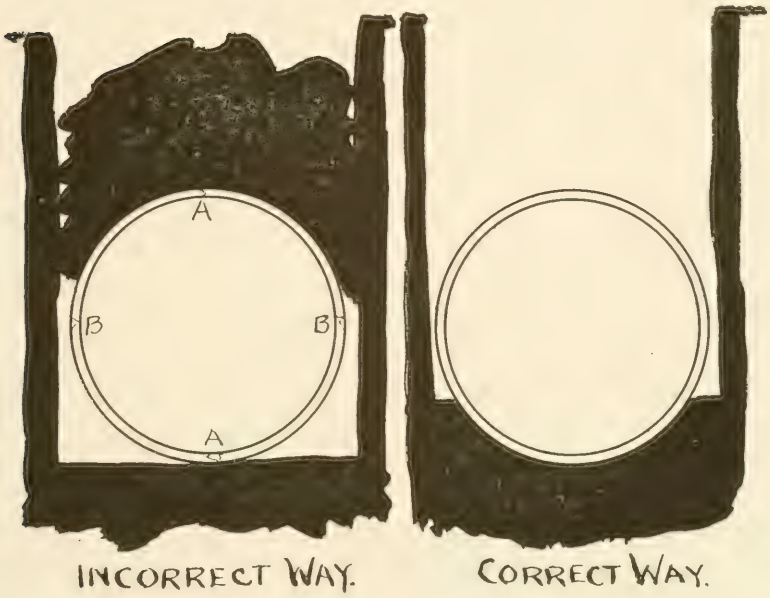


**Fig. 6—Placing Tile in Ditch by Means of Tile Hook.**

asked the rates per rod that he charged for his work, he gave the following figures: 45 cents a rod for 5-inch tile, 50 cents a rod for 7-inch tile, 55 cents a rod for 8-inch tile and 65 cents a rod for 10-inch tile. This, of course, includes digging, tiling and filling; in fact, completes the work. Compare this price for the number of rods to be drained with the cost of digging by hand and if your estimate is correct you will find that the ditching by machine is cheaper. Remember also that it is done with more accuracy, gives you a straight ditch, a correct fall in the drain and a true alignment of the tile.




The above illustration shows the correct and incorrect methods of laying large tile. In the figure on the left the dirt thrown in on the tile bears an unnecessary weight upon the point A. This is apt to cause strains at the points A and B due to fact that the tile has no support underneath except at the very bottom A. The correct way to lay large tile is to imbed it about four inches as shown in the sketch on the left. This gives it a firm support and the weight of the dirt thrown in will not affect it at all.

# IMPROVEMENT OF OUR RURAL HIGHWAYS

## THE IMPORTANCE OF SUB-DRAINAGE IN ROAD CONSTRUCTION

**The Need of Good Roads** The fact that crops must be marketed, together with the knowledge of the shortage of railroad transportation facilities. is focusing the eyes of America more and more on the rural roads leading from the farms to commercial centers and shipping points.

Every progressive farmer should be deeply interested in the subject of road building, for it is of vital importance to him. He is greatly assisted or greatly handicapped if the roads leading from his farm to the point of marketing his products are in good or bad condition.

We are not going to describe in this article the various types of road construction or explain how the rural communities can finance same. We desire only to cite the all-important point, the basic principle in any and every kind of good road construction and prove how essential it is to the life of and the satisfactory service rendered by the rural highway.

A road or highway is no stronger than the earth forming the sub-grade on which it rests. This is a well-recognized fact. Granting this to be so, it is all important that we make the sub-grade as strong as possible. The only way to obtain a satisfactory sub-grade is by proper drainage of the roadbed. The following reasons prove conclusively our contention.

Did you ever stop to consider the point, Why don't our roads rut and cut up in July?

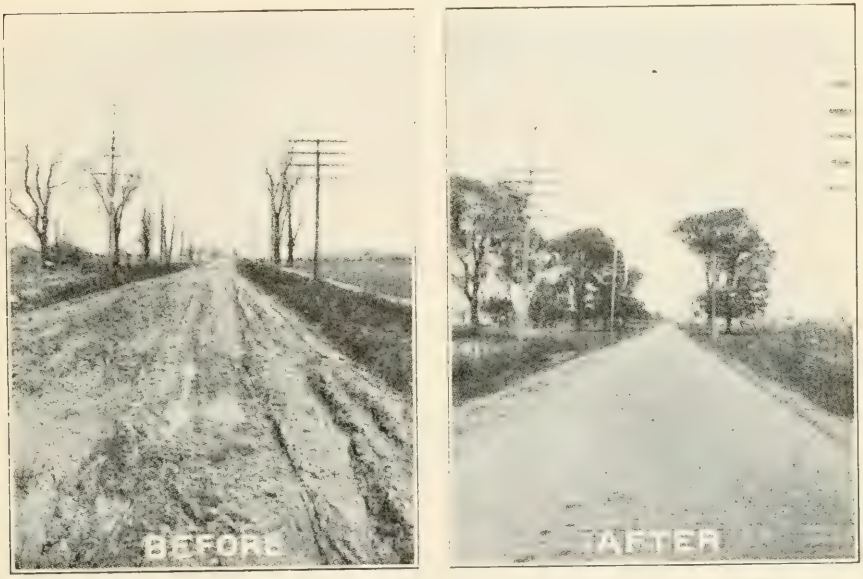
In the summer months of July and August the ground is very dry and the water level low and little or no destruction to the road from any kind of traffic occurs. It's simply because they are dry.

From this we may rightly draw the conclusion that the fundamental principle in road building in all types of road construction is to so build that it shall rest upon a dry sub-grade 365 days in the year. This can only be accomplished through sub-drainage, preventing water from getting in from the sides and coming up from below by capillary action and the waterproofing of the surface by oil or an

impervious material such as brick to prevent the water from getting in from the top.

**The Cause of Road Trouble** The greatest destruction to our roads in this country occurs in the winter and spring months due to the freezing and thawing made possible by the moisture in the ground at that time. In the spring in very wet localities the high water level is a destructive element, frequently causing the foundation to give way.

We must admit therefore that moisture and frost are two ele-




ments that destroy a road. They expand, loosen and make slippery and unstable the soil underlying the road and thus make weak the support of the overlying road surface. We must eliminate these two elements and can do so only by sub-drainage and waterproofing. Surface drainage is all right so far as it goes, but does not prevent an injurious amount of water from seeping into the soil underneath the road. Proper sub-drainage absolutely prevents this in time.

**The Fundamentals of Good Road Construction** Remember this, if you can keep 4 feet depth of road dry 365 days during the year, that is all that is necessary to have a good road. A permanently dry sub-grade gives perfect assurance against underneath injury, which is the general cause of failures of

road surface. The hard surface road will do away with oil and especially if it is brick, it will be dustless and almost everlasting, giving the horses a sure foothold and insuring easy traffic during all seasons of the year.

One string of tile under the center of the road is not sufficient simply because it draws the water to the center. A string of tile on either side of the roadbed draws the water away from the roadbed. The proper sub-drainage, according to an expert road builder, is given in the following letter written by W. P. Graham of Rochelle, Ill., highway commissioner of Ogle County, Illinois, who has been doing a grand good work constructing roads and backing up his knowledge

Tile Trenches 18 Feet Apart.

and experience with enthusiasm and earnestness in behalf of the taxpayers in his portion of the state.

**A Successful Plan**

"It has proven in years past that all types of construction, even the building of large buildings or of anything where a foundation was necessary, that unless the foundation was put in upon sufficient soilbearing support, there was a great deal of danger of settling from which serious damage results. Taking this broad view of road work and knowing the condition of many of the dirt roads in this state and yours and large sections of other states, I concluded several years ago that the fundamental principle in road building was sub-drainage.

"During the past five years I have had a great deal of experience in farm drainage from the standpoint of owning land and tiling it out, and have seen the result. My observation has taught me that when

anything is constructed where the ground under the construction is apt to be affected by moisture more or less, that it is absolutely necessary to use tile in order to bring about a dry condition that warrants the making of a good foundation uniformly stable. This being true in nearly every other line of business, I concluded that it was no less true in road building and that the only thing was to work out some thorough, practical system where it could be installed in the foundation work of road building, and without any question would give permanent results.

"The result of this work was to decide that the proper system in road work was to run two strings of tile parallel with the road 18 feet

Sub-drainage Would Remove This Condition.

apart, or each string 9 feet from the center, using a 6-inch tile and laying it all from 3½ to 4 feet or better, in accordance with the outlet, then grade the road with 50 per cent. less crown than you would if the road was not tiled, allow the grade then to settle for one year or more, keeping it dragged, then sweep it well and oil it, and you have a 365-day road for all time with a small cost in maintenance, for the 18 feet between these tile will get drier and harder every year. In five years the moisture is practically eliminated from the 18 feet of ground, and consequently during the winter months very little frost will enter this part of the road.

"When you have produced such a condition, and it is absolutely possible to do this, you have the highest type of dirt road construction, and there is no road better to drive on than a good dirt road. And should one want to make a hard road of this, you have the very

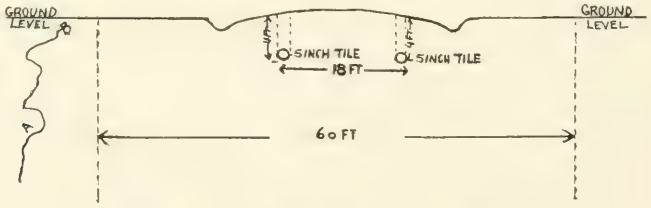
best foundation and will need only half as much material to build the hard road, thereby eliminating a lot of expense, to say nothing about a good dirt road until such a time as the hard road is necessary.

**The Cost** "You doubtless will say that such a plan is all well and good, but it costs too much. Such is not the case, for I have sub-drained several miles, then with the grading and oiling, taking into account different prices of oil, have expended less than $1,500 per mile. This is based on the present high cost of everything. Under ordinary conditions, when worked down to a system, it can be done for much less. I am trying now to work out such a system, but of course have no control over the high cost of material and labor.

"I feel confident that if this system had been used a few years previous to the present agitation for high-cost-per-mile road construction, it would have saved the taxpayers millions and millions of dollars, and we would have had good roads, too.

"As an example, we had one mile of hard road in our township, with a quicksand bottom, and for many months of the year this road was in a frightful condition because of the quicksand filling with water, consequently weakening the base and destroying the road. The taxpayers found it impossible to keep this road in repair.

"I tiled this road with two strings of tile 18 feet apart, scarified the surface, and added to the surface a small amount of stone, more to clean it than anything else, so I could use an asphalt dressing. Then rolled it well, asphalted the top, and it has been in use four summers and four winters, with very heavy traffic, and they have not made a mark in the road, the resurfacing costing only $1,800 per mile on an average haul of three miles. I could duplicate this job for $350 less per mile, as this was my first experience.




When the water rises up in the ground as of line A to a point at B, the lateral pressure forces towards the tile on both sides and is taken away, so that no water ever gets into the space 18 feet wide and 4 feet deep, directly under the traffic line and the waterproof top keeps it from entering there, therefore, a dry cake of ground that will never give way. Dirt roads can be made 365 day roads in this manner.

"The results obtained here can be obtained on any type of dirt road in any locality.

"History repeats itself in everything, and it has done so in road building, and we have found that all over the country roads built on what was considered a permanent foundation showed in ten or fifteen years to be anything but permanent, because of the capillary attraction of the water below this construction, which some years came high enough to affect the road, and down went your construction. The plan which I have suggested will eliminate every bit of this trouble. It matters not what type of soil you have or how much water you have, it is possible to dry 18 feet of the ground between the two strings of tile, if that space has been properly crowned, oiled, concreted, asphalted or bricked, which will serve as a waterproof top. This system prevents water from coming in from the sides, no matter how high the water level is outside, and then the waterproof top prevents the water entering from the top of the road, and therefore you have dry space of ground the depth of your tile, which is the best type of foundation for any road.

"I believe the thinking people of today who are following this road question are almost satisfied that a brick construction on a much traveled road is practically the only road that will hold up outside of dirt when a dirt road is dry. Where the road is excessively traveled, the dust, so injurious to most crops growing near the road, is eliminated by the use of brick for the wearing surface. For this reason this road question, in my judgment, resolves itself to this: if we will tile our roads and then grade them and allow them to settle two years and oil them, we will have the best roads in the world until the time comes when we can afford the brick, and on much-traveled roads the brick road will eventually be put in. Thus, if the dirt road has been subdrained previously, the brick road when built will have the most satisfactory foundation possible."

Mr. Graham accepted the office of township highway commissioner under the single commissioner plan, to serve his people to the best of his ability in securing good highway construction. His well-merited success is shown in the many miles of excellent roads he has built near Rochelle, Ill., and the great reduction he has made in the cost of making same.

Mr. Graham built the road mentioned seven years ago. We wrote him recently asking for information regarding its present condition and as to recommendations he cared to make at this time. In reply we received the following letter:

Rockford, Ill., Nov. 7, 1921.

Mr. J. E. Randall, Indianapolis, Ind.:

Dear Mr. Randall—I can offer you no change in my plan of the sub-drainage of roads, and, further, I think more of the plan each

year. The road I built has been used now seven years, with very heavy traffic, and is in excellent condition today, and it cost $1,800 to surface it.

The edge of that road, or new surface, is not over 3 to 4 inches thick, and yet I would be only too glad to have you drive an 11-ton tractor, with inch-and-a-half lugs on the wheels, on that road, and put the big wheel right on the edge, and you will not destroy it. It has been done a number of times, and not long ago, when I examined the road, it was all there. The original bed of this road was water and quicksand.

The two strings of tile are sufficient; it will do the business and do it right.

I cannot understand why people do not seem to see the practical part of the sub-drainage of road beds.

Very truly yours,
W. P. GRAHAM.

It is claimed by some of our leading men in road-building construction that breaks in the surface of a cement road are not due to expansion, but instead are caused by contraction. They have it worked out scientifically and as nearly accurate as these matters can be determined, and inspection of roads with cross-breaks indicate that they are right in their analysis. They claim that the lengthwise cracks are caused by water running off the edge of the hard surface and puddling underneath the slab, so that for considerable space the concrete rests on nothing and is merely a bridge resting on the high point of the sub-base, and that when the traffic becomes heavy enough it will break down. All of this proves that the sub-base should be bone-dry and kept so.

Mr. Graham had a certain type of soil to consider in his section of Illinois and we heartily indorse his method, but we would go a step further. The far greater area of soils in the country are of a plastic character, through which water seeps slowly, but when once saturated renders the soil exceedingly unstable, and, if frozen, expands and later contracts with great force, effecting severe injury to the road surface.

**An Ideal System of Sub-drainage**

Mr. Will P. Blair, a member of the Committee on Sub-grade and Its Relation to Road Surfacing and Traffic, of the Federal Highway Council, which is carrying on some splendid research work along this line, in a recent conversation with the writer advocated the following treatment which he believes (and, indeed, it appeals strongly to me) will maintain a sub-grade of such soils in a dry condition, preserving the roadbed from injury resulting from both capillary and lateral water saturation and securing a maximum stabilization. In farm drainage capillary

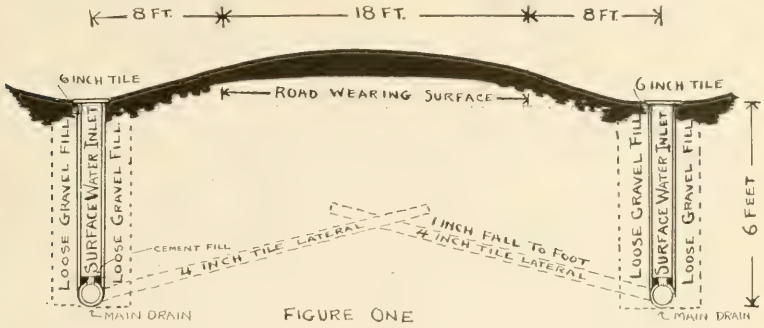



FIGURE ONE

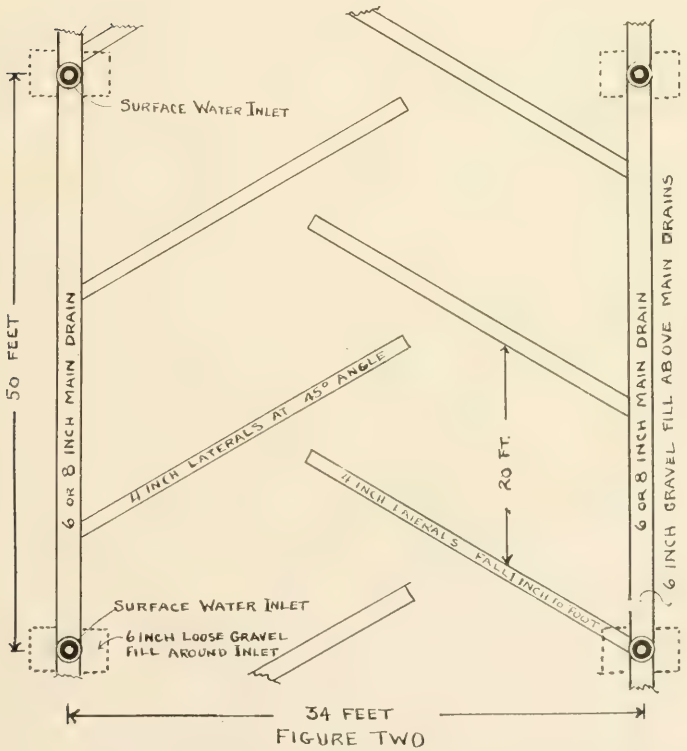

SURFACE WATER INLET
50 FEET
6 OR 8 INCH MAIN DRAIN
4 INCH LATERALS AT 45° ANGLE
20 FT.
4 INCH LATERALS FALL 1 INCH TO FOOT
SURFACE WATER INLET
6 INCH LOOSE GRAVEL FILL AROUND INLET
6 OR 8 INCH MAIN DRAIN
6 INCH GRAVEL FILL ABOVE MAIN DRAINS
34 FEET

FIGURE TWO

Two Sectional Drawings of a System for the Sub-drainage of Roads That Will Eliminate Entirely Any Danger From Water and Make the Sub-grade Dry 365 Days in the Year and an Extra Day in Leap Year, Guaranteeing for All Times Ideal Road Conditions.

water is very beneficial, but in road drainage it is detrimental. We must remove every chance for moisture in the sub-grade, hence the system of sub-drainage must be more elaborate, and with this thought in mind Mr. Blair's system has much merit.

The disposal drain is placed 8 feet either edge of the wearing surface of the road; this receives surface water flow through the surface water inlets, also flow of water from lateral drains placed underneath the road, as well as all the seepage water estopped by the perpendicular of coarse gravel, broken stone or slag extending from main drain 6 feet below the surface to a point near the top of the ground.

The lateral drains underneath the roadway are placed (according to the character of the soil) 10 to 20 feet apart, with a fall of 1 inch to the foot, and leading into the main drain at an angle of 45 degrees.

The placement of the lateral lines underneath the road at such shorter distances apart than is required in farm underdrainage is deemed advisable for the prevention of the capillary action and to thus keep the road in a drier condition than in the other system.

**Advantages** The system is below the influence of frost, taking away moisture in winter as well as in summer.

Eliminates extraordinary expense of upkeep of the open ditch, which, if it functions at all, must have constant attention, especially in the spring of the year.

Eliminates expense of keeping the roadsides mowed, which can be done only by hand, in case of the open ditch, but installing system as outlined roadsides can be mowed with ordinary farm horse-power mower, and the field can be cultivated much nearer the roadside, increasing materially the area to be farmed.

Eliminates the dangers of accidents caused by the menace of the treacherous open ditch.

We must bear in mind that the almost universal method of drainage is the construction of big open ditches on the side of the road. But observation as to their behavior and the disadvantages of this character of drainage needs to be given careful consideration to arrive at an answer as to whether or not it is the best and most economical method for securing the results wished for.

In the first place, the construction of these side ditches costs a lot of money. It costs a great deal more to maintain them. In the winter, following a frozen condition, with a succeeding rainfall, they become dammed up at places and do not function. Instead we have a system of reservoirs along the side of the road by which moisture is supplied to the sub-grade by capillary attraction, furnishing to the roadbed and sub-soil underneath the very element of destruction which we wish to avoid. More rain, greater saturization and more frost, ends in the complete destruction of the road, so that it is made entirely unfit for

travel. Then again, in the summer time, when we go to mow the weeds and briers from the roadside, the expense mounts high, when if the same operation could be performed with a mower the expense would be insignificant.

Again, these open ditches by the roadside are and always were a hazard of danger, and particularly so now, when so many automobiles are used upon the road; these side ditches are as dangerous to life as if the precipice was multiplied to one hundred feet. The destruction resulting from a plunge into the ditch is equally fatal.

Contrasted with this method of drainage, and at no greater expense in the end, is the resort to the more liberal use of drain tile. This can be placed as disposal drains on either side of the road and takes the place of the open ditch. Below the freezing point, they will work at all times, winter and summer, whenever there is sufficient moisture in the ground to be carried to a final disposal place. Then frequent drains underneath the roadbed itself, leading to the disposal tiles on either side of the road, will tend to prevent the roadbed saturization from capillary movement of moisture. The direct rainfall can readily be cared for at manhole openings located at short distances from each other. In soils through which water flows exceedingly slow, this system can be supplemented by placing over the entire area thus tile drained a layer of broken stone, gravel, rotten rock or slag; this will both accelerate the flow of water to the tile and prevent any flow of water by capillary action into the upper structure of the road.

Thus the employment of a liberal use of drain tile for road drainage not only affords, but it is the only manner at present known of successful road drainage. It does not entail the everlasting annual expense and functions efficiently for the purpose, so that in the end it is far less expensive than the open ditch.

The use of drain tile for road drainage in this manner is of equal importance regardless of the character of the wearing surface. It adds to the durability of the brick road and is absolutely essential to the life of a road of any character. Even a graded dirt road is benefited much beyond the expense necessary for the installation of a drainage system by the use of the tile, making the drainage structure a permanent and lasting one and thus eliminating a recurrence of expense which has become an annual tax and a great burden to road upkeep throughout the country.

We want to emphasize the necessity of the farmers keeping constantly in mind and to strongly insist when the subject of good roads is under consideration in their community, that the all-important item in good road construction—proper sub-drainage—is adhered to.

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